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Ingenio pollet: omnibus Arte præit.

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A Light
To the Art of
GUNNERY.
Wherein the most necessary
points belonging to a
ner either in Sea or la
Service are made Practi
cable, And faithfully se
By Capt. Tho. Binning.

A LIGHT TO THE Art of Gunnery.

WHEREIN

Is laid down the True Weight of Powder both for Proof and Action, of all sorts of Great Ordnance.

Alſo the true Ball, and allowance for Wind.

WITH

The moſt neceſſary Concluſions for the Practice of Gunnery, either in Sea or Land-Service.

LIKEWISE

The Ingredients, and making of moſt neceſſary Fire-Works: As alſo many Compoſitions for the Gunner's Practice, both at Sea and Land.

By Capt. *THOMAS BINNING.*

LONDON;
Printed by *J. D.* for *W. Fiſher* and *R. Mount*, at the Poſtern on *Tower-Hill*, 1689.

A LIGHT

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Art of Gunnery.

To the Reader.

Judicious Reader,

I *Am perſwaded there are none, tho but mean Artiſts, that will queſtion the worth of the Art of Gunnery, being founded upon the two principal Pillars of the Mathematicks,* viz. *Arithmetick and Geometry. For by this Art and good Artiſts, the Artillery hath gained Battels, Towns, Caſtles, Citadels and Forts; yea, the ſtrong Trenches of a ſtrong Army forced, opened and ſtormed by the weaker Army, to the ruine of the Intrenched Forces; which was ſeen at the Battel of Lutzen, in* Novemb. 1631. *where the Serene & Potent* Guſtavus Adolphus *K. of* Sweden *was killed; for there the Swedes Gunners did ſo artificially ply their Ordnance, that the Swedes Army ſtormed the Imperialiſts in the moſt ſecure Trenches that could be made, and a ſtronger Army within than thoſe without; and only by the Artificial and Induſtrious Carriage of the Gunners. By which you may perceive, that there is as much lieth on the uſing of the Ordnance, either by Sea or Land, to the ſafety of the Ship, Gariſon, or Army, and annoyance of the Enemy, as upon any thing elſe.*

In this little Piece you may find the framing thoſe Draughts, the Calculating thoſe Tables for Powder and Ball, and laying out thoſe Height-Rules both for Powder and Shot, the true Wind of every Gun, with the Dimenſions of their Fortifications in giving Pouder, not having regard at all to the weight of the Peece; further, as for the Draught of the Ordnance; likewiſe what is uſeful to a Gunner either by Sea or Land, and how the Gunner may lay or level his Peece to ſhoot at a Mark, alſo ſeveral Queſtions a Gunner ought to give ſome account of ere he be admitted: As alſo to uſe his Mortar-Piece and Petard, with Fire-Works Offenſive and Defenſive. Whereby I am perſwaded, any that will take notice of the uſe of the Quadrant & Quadrat, and Obſervations thereon, will find as Artificial Recreation in this little Piece, as in any hath been written hitherto on this Subject.

To the Reader.

It is visible, the great harm that cometh by breaking of Guns in firing, is the ignorance of those Gunners, and the great allowance of Powder; for if a true-fortified Piece of Ordnance shall have to 9 ℔ Ball 7 ℔ of Powder; the Question is, What ought to be given to a Reinforc'd Piece shooting the same Ball? This and other such Businesses moved me to write, that thereby Gunners might be more circumspect.

I have not done this, that thereby I may add any thing to the Artificial Gunner, but that the younger Brethren may, by reading & observing what is here made plain, learn to do their Duty.

If this Piece do instruct any yet ignorant, I shall be glad; if it please the Reader's fancy I have content; but if it displease any critical obstinate Maligner of the Art, I shall take no more notice of him, but desire he may amend himself and this also: Nevertheless conclude as thou findest, and consider the good will of

Thy Friend, T. B.

To the Praise of his Country-Man Capt. Thomas Biuning.

IN this little Book I plainly see
Inventions rare, with Art of Gunnery,
Grounded upon two Pillars that must stand,
While God and Nature Earth and Sea command,
Arithmetick, *Geometry*, with new Inventions,
Thy King and Countries Good, be'ng thy Intentions.
Therefore *Minerva* claims Ingine and Wit,
And Mighty *Mars* does own this subject fit.
See'ing from our Country-Man it doth redound,
(Whose Country hath been formerly renown'd)
Let us not keep from him deserved Bays,
Which Strangers would afford as his due praise,
Because he' hath given a Light to Gunnery;
Not craving therefore Gold or other fee,
I do conclude, the like hath not been wrot,
In any Language till now by a Scot.

Tho. Orquart.

An

An Introduction to the GUNNER, *for his better Understanding.*

THere are many who do intrude, and also that have obtained the preferment to be Gunners, either of Garisons or Ships, who never understood any the meanest or least Article (as I may say) in the Gunners A, B, C.

I speak not this to discourage any from ingaging in the employment of a Gunner; But I am sure, except he be qualified with the Principles and Ground-Rules of Gunnery, he cannot be worthy of the place. And yet there is more than Art or Action to be obtained ere they begin: For which Cause I will here begin with those Qualifications, that a Man professing, and dignified with the trust of a Gunners place, ought to have.

1. That he be one that feareth God more than his Enemy.
2. That he be educated, and expert in his Profession: for Experience confirmeth, some say, teacheth Art.
3. That he be constant, and not given to change.
4. That he be Faithful, True and Honest.

The Reason wherefore my first Discoure is of Gunners, is only because many times it falleth out, that most Men employed for Gunners are very negligent of the fear of God. Many Examples of this nature might be alledged and produced from the sad experience of preceding times: But I thought good to intimate only this one, for the terrifying of all Godless, and the confirming all Godly Gunners: Which Example I had from *Seyger van Reghterne*, General of the Land of *Overyssel*, in his Diurnal from *Amsterdam* to *East-India*, the which Diurnal begun on the 8th day of *December*, in the year 1628, from *Texel*, and ended there at his return the 12th of *July* 1633. In the 38th Folio of that Book, he saith, That in the year of our Lord 1631, in the Month of *April*, There was on the Island *Nero*, a Gunner, whose Name was *Cornelius Slime*, but a very Godless and profane Man, who at no time could speak but he would be Cursing or Sweating; and when any would ask him what was his hopes after this Life was ended, his

his Answer was, It may be to Heaven, or it may be to Hell; but, said he, if I do go to Hell, there I will sell Tobacco and Brandy, and that would be good Medicine for the Devils. But one day this *Cornelius Slime*, in presence of my Author and many more, being Cursing and Swearing, and many times giving himself to the Devil; in the mean time, in presence of all those People, the Devil lift him up in the Air, and let him fall to the Ground, with a great noise; but the second time being taken up by the Devil, he was carried where never Man living could find him. From the like the Lord deliver us all. But if Experience had not taught me, both in this Country and others, what the lives of many Gunners are, I would have said nothing of it here.

Now for the Education of Gunners in their Profession, it was manifest that there were not any of the Gunners imployed by the Officers of the Army, in our King's and Countries Service, all the while his Majesty was in *Scotland*, which were capable of their Duty, or knew any thing of Art; and it was no Wonder to see our common Gunners so slothfull to attain to perfection in Art, because if there had been a Man able in his Profession, our Officers of Artillery would not employ him, lest he should see, and so reveal their own Insufficiency. Likewise they needed not care what their Abilities were, for those that had charge over them, durst not put them to examination, for fear their own Insufficiency should be openly known, but if they had bin able to put them to it, we might expect to be better Masters of this Art, when now we are scarce good Scholars. Likewise when there were able Men in the Country, they could have no Imployment; and for fear they should be employed, there was one Calumny or another raised to their prejudice; either he is proud, or a Malignant, which was in effect, he was a true Subject, and therefore not to be employed; and any of these two Names were enough to keep him from imployment; or if he was in Service, to cause him to be Cashiered, as the Case then stood.

But to encourage Ingenious Spirits to study Art, and to practise the same, Remark what is said of the Emperor *Domitian*, That he was so skilful in shooting, that let a Boy a good distance off hold up his Hand, and stretch forth his Fingers, and he would shoot through betwixt his Fingers with an Arrow, and not touch the Boy. Now I am sure, that although the like may not be done with any great Piece of Ordinance, yet I have seen one, who shooting with a great Piece, within point-blank of the same Piece, after Observation and Tryal of that Piece, would shoot within a hand-breadth of any Mark; yea, set a drinking-Cup on the end of a Pike, he would take it with a Ball. And because I

have

have been both at Field, and Sea-Service, and have ſeen ſuch Errors in Gunners, my Deſire is, That thoſe that are in Place, or ſhall come to it, may exerciſe themſelves, and ſtudy to better their own Credit, and act ſomething for the Benefit and good of their Country, and honour of their King.

As for the Conſtancy of Gunners, and others; Hath it not been ſeen ſince the beginning of thoſe comfortleſs Troubles in theſe Nations, the unconſtancy and inſtability of Men, how they have varied from the one Party to the other? yea, they have for Ambition, and greedineſs of Gain, fled from the Army they have been ſworn to, and gone to the Enemy, to the great loſs of their own Souls, and hazard of the Truth, and an undoubted advantage to the the Enemies of his Majeſty.

For their Honeſty, they are not ſo much to blame as thoſe that have the charge of them; for were they drawn to an account of what they receive, and how they have ſpent it, then Men durſt not but be honeſt.

But the Commiſſary taking from each Barrel 10 or 12 pound weight of Powder, the Gunner finding this, muſt be let ſlip with as much; and I think 20 or 24 pound in the hundred, is a large Intromiſſion. *Probatum.*

Now to help this great, and I may ſay, terrible Theft commited againſt King and Country; And that the Ammunition may redound to the profit of the Country, which is the only Service his Majeſty requires, Chuſe honeſt Men for Commiſſaries, and Keepers of the Magazine, who will require an exact Account of what is gone or ſpent, and let every Man be content with his Wages. It is a true ſaying, and the Word of God clears it, *Bleſſed are the Peace-Makers, for they ſhall be called the Children of God*, Mat. 5. 9. Wherefore all Men ought with all their Hearts, to cry to God for Peace with Truth, the which I pray God to ſend us.

To any vers'd in Military Affairs, is known the great Gain or Loſs which may redound, either to the Country, Army, or Fleet, by the well or bad managment of the Great Ordnance, or Train of Artillery; for which cauſe, I ſay, it is moſt neceſſary to try ſuch Men you chuſe to be Gunners ere you truſt, either for Land or Sea-Service: And if they be qualified with theſe forenamed Marks, then are they fit to act the part of a Man: But it is God by whom increaſe muſt come.

Now if there ſhould chance a Man of good Qualifications to be admitted for a Gunner, and but meanly expert: To them I ſay, If they follow theſe following fundamental Rules and Inſtructions, I hope they ſhall have pleaſure and profit.

As

As it is without all queſtion or contradiction, that there is nothing more holy, more profitable or neceſſary than a peaceable Condition; for Peace is the neareſt thing to God; in regard where Peace is, there is Love, Charity, Faith, and all the Vertues: Therefore we ought to pray for Peace, that ſo living in obedience to God, our King and Rulers, we may proſper in this World, and live in Bliſs eternally.

But in regard that the great Princes of the World may obſerve and ſeek Peace, we ought to pray, That as God hath placed them in Power, ſo he may direct them in all their Actions, to do nothing contrary to his Glory, or the good of their Subjects. For what diviſion amongſt the Kings and Princes in Chriſtendom, hath done to the deſtruction of Religion, effuſion of Blood, and ruining of their Eſtates, is much in Hiſtories made plain: And what hath been done by our unnatural Diviſions within theſe three Kingdoms, is yet freſh in memory, to the great grief of many good Chriſtians. And in regard that ſome Princes in Chriſtendom are forced to keep War, for maintaining of the Chriſtian Faith againſt Turks, Saracens, and barbarous Tartars; As alſo that amongſt themſelves, ſome are either blown up with Pride, or Envy, who would Reign alone, much amuſing the minds of Men what they intend to do; ſo that War is as like to be as ever: Therefore any well-wiſhing Perſon ought to ſtudy for the advancement of his Kings Honour, and good of his Country.

Now what may be the Actions done by great Ordnance in time of War, may be thought either needleſs or hurtful: Becauſe there is nothing thereby to be taught, but to raze down Fortications, and other Strengths to ruine: Or how an Army, by cutting off the Souldiers, may be ſhattered and broken, and an intrenched Leaguer may be broken up and forced.

Truly ſuch Men ought to be in eſteem, if we will have any reſpect to theſe dangerous Times wherein we live, they ought to be encouraged; becauſe no Potentate can be longer in Peace than his Neighbour pleaſeth: and that ſcarce any Strength is able to reſiſt the fury of terrible Cannon well managed.

And amongſt all Arms in time of War the great Ordnance is firſt in uſe, whether it be againſt, or in a beleaguered Place; and eſpecially when they are rightly managed with diſcretion, they are both helpfull and encouraging to their Party.

And contrary, when they are not Men of Judgment and Diſcretion, but ſlothful, and ignorant, then they produce dammage to the owner of them. For, as Hiſtory declares, the great Ordnance hath been the only Winners of the Battel ſometimes, and great Victory, when they have

have been well managed, while the oppoſite Party gave their Ordnance only the blame of their flight, becauſe they were not well managed.

What a Gunner ought to be, to whom the Charge is committed, and what he ought to know.

As it is neceſſary in all Fortified Places, as well in time of Peace as of War, to have able practiſed Gunners, who are able to give an account with reaſon of the things belonging to their Charge; and that they be ſuch as fear God more than their Enemy, they ought to be honeſt, and not given to change, as afore is ſaid.

The Gunner ought, beſides his true ſhooting, to be learned in Arithmetick and Geometry, which will cauſe him give advice where a Strength may be moſt conveniently battered, and what Ordnance is moſt fitting to accompliſh the ſame.

Alſo he ought to give Directions to the Engineer, what form of Batteries is moſt convenient at ſuch and ſuch places: Likewiſe by his Art he give directions, that a Storm be made where his Party may have the leaſt harm, by his playing with Ordnance upon the places where danger is to be feared: Likewiſe if in a Beleaguered Place, the Gunner is to defend the ſame againſt oppoſition of the Enemy, and to order ſo, as by the aſſiſtance of the Ordnance, and by what other means he can, to oppoſe and deſtroy the Enemy for defence of the Place.

But before all things, and before the Army approach to the Place, to which the Prince, General, or other Officer who commands in chief, do intend to beleaguer or take; It is neceſſary that the experienced Gunner be one to go before, and view the Place, with the Ground thereby; the which to do, is beſt at breaking of the day in the morning, to know if the Walls be ſtrong or weak, and how and by what means they may be brought down; as likewiſe to find if that Fort or Gariſon be ſo fortified, as to annoy the Ground, or what part thereof is moſt ſecure for the Army to lay down Leaguer; and what Ground is beſt to annoy the Enemy moſt in the Gariſon, and alſo what place of the Walls thereof is beſt to Batter and Storm, and which way moſt ſecure to bring the Scaling Ladders to ſet up; and to know if there be any Mount, Steeple, or high Building within that is Fortified, to over-look the Leaguer; for by ſuch means great harm may occur, (or near the Leaguer) where the Enemy may over-look and relieve the Beſieged, and ſo cauſe the Leauguer to riſe;

except the Ordnance in the Leagure be capable presently to disorder and deface the same, that after the Leaguer is intrenched, it may be defended by Ordnance, &c. Then he must know if the Ground be diggable, and on what Side of the Leaguer the Proviant may be best and most securely brought in, and what fresh Water is there-about for their relief within command of the Leaguer-place: So when it is known where, on what end of the place or Side the Great Ordnance must be placed, and lie from or in the Leagure, then must the Batteries be drawn out and measured; and because it is hazardous to work on a Plain, to break Ground before an Enemy, but there must Blinds be raised, some must be where you are not to work, as well as where you intend to build your Batteries: But if you be on such Ground where you must begin your Approach at a distance, then you must know at what distance you may with conveniency break Ground to run your Trenches for Approach; and as it is certain the Point-Blank Distance of a Peece of Ordnance is 220, 230, 240, 250 Geometrical Paces, which is also the distance of a Musquet-shot; Therefore the knowing Gunner ought to give the Workmen order, if there be no other Engineer for the Effect; and in this regard the Gunner ought to be acquainted in Surveying for this, as well as for his Batteries and Ordnance placing: For if one would begin an Approach, then he must chuse out so many Souldiers used to Work, as may be able to defend themselves and resist a Sally, if any be: Not neglecting to have Parties both of Horse and Foot about the Ground to defend them; in regard they are to carry, besides their ordinary Arms, Shovels, Pickaxes, Gavelocks, Crows, and what is necessary for their Work. At the place commanded to break Ground, it is fitting to cast up a Redoubt or two, from whence the Trenches are to begin; and run the Approaches, that if any suddain Assault come, the Workmen may retire thereto and defend themselves, and work till they have assistance: for if the Workmen had no place of present retreat, they would be forced to run and leave their Work, Tools, and Arms to the Enemy. To this purpose it is to be observed, That the expert Gunner, or Engineer, who is employed in this Work, is to use all the Art, Skill, and Experience they have, to run their Lines in such sort, that those which are in the Trenches and Approaches may not be discovered and seen by the Enemy, so that with safety and expedition they may approach near the place, or part of the Fortress, which the General desires to become Master of.

For now in our Modern Fortifications, there are but two parts in a Town or Fortress, of which one must be battered if they mind to take it in; and these are either a Bulwark or Curtain. When

When the General or Commander of the Field, by advice of the Council of War, hath reſolved either to batter a Bulwark or Curtain, the Gunner or or Engineer being preſent at the breaking of Ground, is to ſhew and inform the Workmen how they are to run their Line, and, as the occaſion preſents, of divers lengths; for they muſt be turned at every juſt occaſion, which is moſt neceſſary. When the Line is laid out and marked, the Workmen muſt be divided and placed in order, that one may not hinder another: Then to give to every Workman the length of 4, 5, or 6 foot, and then begin they to haſten into the Ground, for to avoid the danger which they are expoſed to, while they ſtand upon the Earth; Therefore the Earth which they dig, they caſt up before them, and as faſt as can be make a Hole like a Grave; ſo when they have digged three foot in the Ground, and three foot broad, then ſure they are covered, ſince from their Baſis to the top of the Caſt-up-Work there are ſix foot: When they are under Covert, then they enlarge and deepen the Approaches as they are ordered: Obſerve, they need not be ſo deep at the beginning as near to the Fortreſs; ſometimes the Trenches muſt be made ſo broad, as that the Cannons and Wagons of Proviſion muſt be drawn to the Batteries or Galleries. Theſe Works are ordinarily begun in the Night; ſo when the Night is gone, there are freſh Men ſent to relieve the firſt, and enlarge the Nights Work, and amend what they could not ſee wrong. After this Nights Work, or the ſame, there are Corps of Guard made to contain Souldiers for a Main Guard, which Work ought to be with a Line of Communication with the Trenches, though they be at a diſtance, *viz.* four or five paces diſtance. When one Line is finiſhed as above-ſaid, and that it muſt be run no further that way, the Gunner or Engineer turns it another Way, bearing it from the Town or Fort, and placing the Workmen as aforeſaid, and ſo continuing by Turnings and Windings, till he hath got ſomething near the Place or Fort beſieged, and making good the Line continually with Corps of Guards and Batteries, until they be at the brim or ſide of the Moat or Ditch of the Fort: Then is the Gunner or Engineer ſo to order his buſineſs, as to begin a Sape or Gallery, or Mine under the Ground, directing his Courſe by his Compaſs; as if Impediment of Rocks happen to ſtop his Courſe intended, he may make ſuch Lines and Angles about the ſame, as may bring him to his direct Line again; no reſemblance to it, but a Mariners Traverſe by croſs Winds at Sea.

But for the effecting of a Mine, there muſt be proviſion made of divers things neceſſary thereunto, as Shovels, Spades, Pickaxes, and

all kind of Maſon-Tools, with all things requiſite to pierce a Wall, wherewith the Rampier is made: Then one prepares Props to ſupport and bear up the Mine from falling or ſinking, being thick and long, as is requiſite; likewiſe you muſt have ſtore of Fir-Planks to line the Mine within that it may not fall down, for it muſt all be lined if the Ground be fruſh or brittle.

Before you begin to make a Mine, it will be requiſite you know the Ground of the place, whether it be vaulted or not, or on what the Foundation thereof is laid: The Miners being to break into a Wall, are to carry their Mine as cloſe and ſecret as may be, that the Beſieged may not hear any noiſe, or get any notice where the Mine is made, and how it runs; for if they do, queſtionleſs they will make a Contra-Mine or Traverſe above Ground, to diſcover and ſpoil your Mine begun; ſo that failing, you cannot force the Beſieged that way, except you begin a new Mine in another place: Such as was at the Caſtle of *Edinburgh*.

The Maſter-Gunner or Engineer that conducts a Mine, ought to be a Man of good Experience, leſt he miſcarry in his Traverſe; for which cauſe he ought to be well acquainted with the Mariners Compaſs, and alſo with the Variation thereof; for if there a Mineral of Iron Ore in that Ground, it is like the Compaſs will vary, and ſo miſcarry the Mine: He ought alſo, for his Lines of Traverſe, to be acquainted with the Line of Chords, or Plain-Scale; otherways with the uſe of the Protractor, for directing his Courſe and Traverſe in the Mine, that he miſtake not himſelf either in his Courſe or Diſtance, Altitude or Profunditude, according to the Ground he works in, and the Foundation of the Rampart. When the Mine is brought to the entry of the place where the Chamber muſt be: Sometimes order may be given to blow the Rubbiſh into the Fort beſieged, or it may be out into the Moat or Ditch; either which may be done by making the ſide thinner, which they would break to, than the other: And our Experience is ſufficient proof of this, either in Cannon or Muſquet; for if you load a Piece of Ordnance, that there be a greater weight put after the Powder than in reaſon, give fire to the touch-hole, and you will find that Piece fly out either at Side or Breech.

The proportion of Chambers are as various as the Wall or Rampart which they are to deface, therefore can have no dimenſion, but they muſt be made ſo large as to contain Powder ſufficient. Some would preſcribe Rules for a Barrel of Powder to blow up a Rod of Earth; but the Earth being of various ponderoſity, and ſome ſo much ſtronger bound than others, that I ſuppoſe they muſt uſe rather more than leſs

Powder;

Pouder; yet the Chamber would not be made larger than to contain the quantity of Pouderordained to open that Breach.

When an Enemy hath beſieged a Place, Citadel, Fort, Caſtle, or other Fortification, and hath approached to Battteries; certainly it behoves the Beſieged to look about them, and to do their utmoſt endeavour to hinder the Enemy. The Defence againſt theſe Approaches is, to ſtrive to make ſome Contre-Approaches; which may be done by ſtoutly ſallying out, but withall to ſally out with diſcretion, for fear of loſing Men, which is to be expected; by which ſallying, the leaſt offence you do the Enemy, is to hinder the progreſs of their Approaches; for if they be beat back, and conſtrained to fly into their Works, for ſo long as the Alarm endureth, they cannot advance their Work, nor begin again to work till the Beſieged be retreated.

Likewiſe this manner of Defence may be made by Cannon, which may play from all places upon the workers of the Approaches, to do them what harm imaginable, which may put the Workmen in Fear, by ſeeing their Fellows miſerably ſlain by the *Cannon, which may be a means to make them leave working till there be Batteries made againſt the Beſieged.

* *By firing ſix Cannon together over the Mine at* Edinburgh *Caſtle, it fell in.*

The Contre-Approaches, by which you reſiſt an Enemy, that they may not become Maſters of your Outworks, or Contre-ſcarf, with their Approaches; Theſe Contre-Approaches, to hinder the Enemy in their approach, are made by caſting up ſome †Traverſes, as I did at the Caſtle of *Edinburgh* againſt the Approaches of that Rebellious Army, running them ſo, as to find the Enemies Mines; The Lines of this Traverſe muſt be caſt up toward the Enemy, but left open to the Beſieged, or Gariſon, becauſe by them they muſt be defended: This Traverſe muſt be ſo made, that it give no advantage to the Enemy if they take them in; and be ſure they may be flanked both with Cannon and Muſquet from the Fort or Gariſon.

† *By the Traverſe I came to the Holt.*

So that as there is an Offenſive War, there is alſo a Defenſive War, as doth appear by Mines; for the Beſieged having diſcovered them, and got into them, may lawfully kill the Miners: Now when the Beſieged have found the Mine out, it is to be known how they may make the way clear before them, and either kill the Miners, or make them fly, without having the leaſt harm.

After the cauſing a Hole to fall in their Mine, near to my Traverſe, I prepared a Pouder-Barrel, with old Rope-yarn, Mens Dung dry about

the

the Walls, Powder meal'd, Brimſtone, and Verdigreaſe, with Camphire; all which being mixed together, I cauſed to be put in the Mine, which made *Overton* (*then Governor of* Edinburgh) and all flie: So we entred peaceably, and brought thereout their Working-Tools without any harm.

For the Gunner's further knowledg, that is yet in his Minority, this Work is begun with *Decimal Arithmetick*, which is very uſeful in the Art of Gunnery, the working and extracting of the Square and Cube Roots; as alſo ſome Definitions and Problems of Geometry: by which the Gunner may the better make uſe of his Compaſſes, for which he will have ſeveral needful uſes; for the whole Matter, I know little in this Book that may be wanting in a Gunner, that may be called a ſufficient Gunner. In fine, know, that I ſhall be glad that every Gunner may profit by it, and I wiſh that ſome may amend it. However, know, that I intend this for your Profit and the Publick Good; for if I had not ſeen need, I would never have taken the Pains, nor been at the Charges; but (underſtand me right) no Pains can exceed the Duty we owe to our King and Native Country. So wiſhing every good Subject to employ the Talent he hath received of God, to the Honour of his King, and Good of his fellow-Subject: Committing the Book to thee, and thee to God Almighty,

I remain thine, to ſerve thee,

THOMAS BINNING.

Decimal

Decimal Arithmetick.

CHAP. I.

Definitions.

A Fraction or broken Number, is a Number less than an Unite, or One; and according to the common way of Fractions, is expressed by two Numbers set one over the other with a small line, thus, $\frac{1}{4}$; the upper Number is called the Numerator, and the lower the Denominator.

The Denominator sheweth into how many parts the Unite or Whole of any thing is to be divided.

The Numerator sheweth how many of these parts are signified by the Fraction.

A Decimal Number is that which is expressed by an Unite, with a Cipher, or Ciphers, as 10: 100: 1000: 10000: 100000: *&c.*

A Decimal Fraction is that whose Denominator is a Decimal Number, as $\frac{3}{10}$: $\frac{46}{100}$: $\frac{214}{1000}$: $\frac{2142}{10000}$: $\frac{17689}{100000}$: *&c.*

Decimal Fractions, whether they stand alone, or be joined with Integers, have always a Comma, or a small Rectangular Line before them, to distinguish them from Integers, which is therefore called a Separating Line, as ⌊4, ⌊36, ⌊348, 4⌊2, 490⌊086, *&c.*

As in Integers the Value or Denomination of Places do increase by Tens, from the Unite place towards the left hand: So in Decimals the Value or Denomination of places do decrease by Tens, from the Unite place towards the right hand: As in the Table following.

The Table.

9. Thousand Millionths.	8. Hundred Millionths.	7. Ten Millionths.	6. Millionths.	5. Hundred Thousandths.	4. Ten Thousandths.	3. Thousandths.	2. Hundredths.	1. Tenths.	0. Units.	1. Tens.	2. Hundreds.	3. Thousands.	4. Ten Thousands.	5. Hundred Thousands.	6. Millions.	7. Ten Millions.	8. Hundred Millions.	9. Thousand Millions.

In

In Decimal Fractions, the Numerators are only set down, without the Denominators; but the Denominators are easily known, for they are the same with the Denomination of the last Figure of the Numerator. As in the Examples following.

Examples.

L6 is { Six. Numerator. / Tenths. Denominator. } The common way $\frac{6}{10}$.

L42 is { Forty two. Numerator. / Hundredths. Denominator. } The common way $\frac{42}{100}$.

L364 is { Three Hundred sixty four. Numerator. / Thousandths. Denominator. } The common way $\frac{364}{1000}$.

CHAP. II.

Addition and Subduction in Decimals.

ADdition and Subduction in Decimals, whether in pure Decimals, or in Integers mixt with Decimals, differ not from Addition and Subduction in Integers, only care must be had to place the separating Lines of the Numbers under one another; as also the places of like denomination under one another; and the separating Lines of the Sum or Difference, must be placed under the separating Lines of the Numbers added, or subducted. See the Examples.

Examples in Addition.

L347	L8972	346L98
L268	L643	74L2
L149	L8	6L934
L764	L79	L8
	3L1302	L07
		428L984

In

In Addition and Subduction, let the place of the Fraction remain so many places as they were, and no more.

Example.

Addition.

35L72
78L05
113L77

Subduction.

78L25
35L75
42L50

Examples in subduction.

L724	L89	L6427	64L279
L482	L5796	L36	48L384
L242	L3104	L2827	15L895
46L2	59L872	74L0	34L2
9L746	6L9	65L98	L642
36L454	52L972	8L02	33L558

CHAP. III.

Multiplication in Decimals.

THe Numbers to be multiplied together, are called Factors; and the Number found out by Multiplication, is called Product.

In Multiplication, whether in pure Decimals, or in Integers mixt with Decimals, is the same in Operation with Multiplication in Integers: The last Numbers of the Factors must be set one under the other, as if they were Integers, not regarding the placing of the separating Lines under one another, as in Addition and Subduction: And from the Product must be cut off with a separating Line so many of the last Figures, as there are places of Decimals in both the Factors.

Examples.

L642	4L27	L489	50L4
L54	3L4	62	2L4
2568	1708	978	2016
3210	1281	2934	1008
L34668	14L518	30L318	120L96

If it happen, when the Multiplication is ended, that there be fewer Figures in the Product, than there are places of Decimals in both Factors (which may often occur when the Product is a Fraction) in such case, as many places as are wanting, so many Ciphers must be prefixed to the Product on the left hand thereof, and then a separating Line must be prefixt to sign the Product so increased for a Decimal.

Examples.

L0375	5L525	12L653
L025	L0026	L00045
1875	33150	63265
750	11050	50612
L0009375	L0143650	L00569385

In Multiplication with Fractions, cut off so many places as there are Figures of the Fractions, in the Multiplicand and Multiplier.

Examples.

320L5	732L05
4L37	26L37
22435	512435
9615	219615
12820	439230
	146410
1400L1585	19304L1585

CHAP. IV.

Division in Decimals.

DIvision, whether in pure Decimals, or Integers mixt with Decimals, is the same in Operation with Division in Integers. But care must be had to give a true denomination to the first Figure of the Quotient; (according to this Rule.)

The Rule.

The first Figure of the Quotient is always of the same denomination with that place of the Dividend, which stands, or is supposed to stand over the Unite of the Divisor.

It will happen sometimes, that the Unite place of the Divisor will stand beyond all the significant Figures of the Dividend, towards the right hand, or towards the left. In this case you must put Ciphers to the right or left of the Dividend, until you come over the Unite place of the Divisor.

As for Example.

If 3L47 is to be divided by cL000462, they must stand thus;

cL000462) 0003L47 (

And the Denomination of the first Figure of the Quotient will be thousands of Integers.

Another Example,

If 34 is to be divided by 642L79, they must stand thus;

642L79) 34L0000 (

And the denomination of the first Figure of the Quotient will be hundreds of Decimals.

Note, That what Ciphers are added to the right hand of the Dividend, immediately next the Integers, must have a separating Line (or a *Comma*) before them.

In Division, the Fractions being equal, the Work is as whole Numbers are.

If unequal, add so many Ciphers to the Dividend, as the Fraction of the Divisor exceedeth the Fraction of the Dividend in places, that you may find your Fraction in the Quotient.

Examples.

26L37) 732L05 (27L76	3L65) 973L25 (266L60
527 4.	730
20465	2432
18459	2190
20060	2425
18459	2190
16010	2350
15822	2190
188	160

Other Examples.

52|75)954|00(18|08
527 5·
42650·
42200
45000
42200
2800

Because the Fraction is two Figures in the Divisor; Therefore I add two Ciphers to the Dividend. As in this third Example,

If in Division I be to divide by a great many Figures, I may make a Table for them. *Example.*

Which is done, first doubling of it, then adding it until nine times, if I will ten, which proves it.

52|678)62794|000(1192|0346
52678···
101160
52678
484820
474102
107180
105356
182400
158034
243660
210712
329480
316068
13412

1	52678
2	105356
3	158034
4	210712
5	263390
6	316068
7	368746
8	421424
9	474102
10	526780

Because the Fraction is three Figures in the Divisor, therefore I add three Ciphers to the Dividend. As in this last Example.

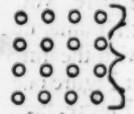
CHAP. V.

Of the Square Root.

A Square Number is that which is made and produced of two equal Numbers multiplied together, or else of one Number multiplied by it self; as 16 is a Square Number, because it is produced of 4 by 4, (which

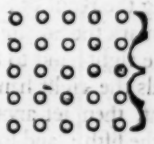
(which are Numbers equal, or one Number multiplied by it ſelf) likewiſe 25, 36, 49, are three Square Numbers, for they are Products of the Multiplication of two equal Numbers, or of one Number multiplied by it ſelf, as 5 by 5, 6 by 6, and 7 by 7. For the Products may be underſtood by their Unites in a Plane, of ſuch kind as ſhall repreſent the form and figure of a Geometrical Plane, as you ſee here under.

The Superfice.



4, the Side of the Square.

The Superfice.



5, the ſide of the Square.

It is evident by the generation of Squares, that you may make a Square of all Numbers given, and that you may extract the Root of all Squares propoſed; and that likewiſe all Numbers propoſed may be the ſide of ſome Square or another.

There is a Double Root and a Double Square, *viz.* Simple and Compound; The Simple Root is that which hath but one Number, as are 1, 2, 3, 4, 5, 6, 7, 8, and 9; the Squares of which are called Simple Squares. The compound Root, is that which hath more than one Number, as are 10, 11, 12, 20, 30, *&c.* the Squares of ſuch are called Compound Squares. And before you will extract the Compound Root, you muſt know by heart the nine Simple Roots with their Squares, by means of the following Table.

A Table of the Simple Roots with their Squares.

Simple	Roots.	1	2	3	4	5	6	7	8	9
	Squares.	1	4	9	16	25	36	49	64	81

To exact all Roots or Sides of Compound Squares, You muſt well underſtand and imprint in your memories the following Chapter.

CHAP.

CHAP. VI.

Extraction of the Square Root in Decimals.

IN extracting the Root or Side of a Compound Square, you must first mark the Square Number given, with Points or Pricks from the right hand to the left, beginning with the first Figure towards the right hand, marking over that Figure one Prick or Point, then set another over the third Figure, and another over the fifth; and so proceeding continually from the right hand to the left, marking still with a Prick over every third Figure, leaving the other Figures unmarked, until you come to the last Square towards the left hand.

```
 . . .
322624(568
25 . . .
-------
 726
 106
 636
-------
  9024
  1128
  9024
-------
  . . . .
```

First find the Simple Root of the Figure or Figures that remain towards the left hand; multiply that Root in it self, subtract it out of the Figures towards the left hand: Then draw down the next two Figures to that Remainder, and say 2 times 5, the Quotient is 10; set 10 under 72, and see how often it may be found in 72, say 6 times; then set 6 under 6, and set 6 also in the Quotient; then multiply 106 by 6, cometh 636, subtract it from 726, there remaineth 90: Then draw down the next two Figures to that Remainder, and say, 2 times 56 in the Quotient is 112; set 112 under 902, and see how often it may be found in 902, say 8 times; then set 8 under 4, and set 8 also in the Quotient, then multiply 1128 by 8 cometh 9024, subtract it from 9024, there remaineth nothing; so that 568 the Quotient is the just Root of the Square Number 322624, &c.

Another.

Another Example.

```
 . . .
75930(275]553
4 . . . .
-----
359
 47
329
-----
 3030
  848
 2725
-----
 30500
  8808
 27525
-------
  297500
   88108
  275525
-------
  2197500
    881108
   1653309
-------
    544191, &c.
```

CHAP. VII.

Of the Cube Root.

A Cube is a Solid Body, comprehended of six equal Square Superfices, and is like unto the Dye of a Table-Board.

Defini-

Definition.

Definition of the Cube Root.

Every Number multiplied in it ſelf maketh a Square Number, of which the Root or Side is the Number multiplied; and every Square multiplied by its Root, maketh a Cube Number, (by the 20th Definition of the 7th Book of *Euclide*:) As 4 times 4 makes 16, (a Square Number, of which the Root is 4) the which 16 being multiplied by the Root 4, the Product giveth 64, a Cube Number, of which the Root is 4.

Likewiſe 5 times 5 maketh 25, a Square Number, which being multiplied by its Root 5, the Product giveth 125, a Cube Number, of which the Root is 5, and ſo of others. And before you can extract the Compound Cube Roots, you muſt firſt know the nine Simple Cube Roots, with their Squares and Cubes. As appeareth in the following Table, which is divided in three Lines, whereof the firſt (which is the uppermoſt) containeth the nine Simple Roots; and the ſecond Line (which is the middle Line) containeth the nine Squares; and the third Line, which is the loweſt, containeth the Cube Numbers.

A Table of the Simple Roots, with their Squares and Cubes.

Simples										
	Sides.	1	2	3	4	5	6	7	8	9
	Squares.	1	4	9	16	25	36	49	64	81
	Cubes.	1	8	27	64	125	216	343	512	729

CHAP. VIII.

Extraction of the Cube Root in Decimals.

TO prepare a Cube Number for Extraction, put a Point over the firſt place thereof towards the right hand, (to wit, the place of Unites;) then paſſing over the ſecond and third places, put another Point over the fourth; and paſſing over the fifth and ſixth, put another over the ſeventh, and in that

that order, (to wit, two places being intermitted between every two adjacent Points) place as many Points as the Number will permit: So 157464 being given, you are to place the Points as here followeth; and so many Points as are in that manner placed, of so many Figures the Root demanded will consist.

Having thus prepared your Number, you may see it distributed by the Points into several Cubes: So in the same Example 157 is the first Cube, and 464 the second.

```
 . .
157464 (54
125 ...
-----
 32464  Resolvend.
-----
  75
   15
-----
  765   Divisor.
-----
 300
  240
    64
-----
 32464
-----
 .....
```

First, Find the Simple Cube Root by the preceeding Table of 157, which is 5; subscribe the Cube of that Root under the first Cube of the Number given; so 125 being the Cube of 5 the Root, I write it under 157 the first Cube of the Number given, and subtract this Cube from the first Cube of the Number propounded, placing the Remainder orderly underneath the Line: So 125 the Cube of 5, being subtracted from 157, the Remainder is 32: to the said Remainder, bring down the next Cube of the Number propounded, (to wit, the Figures or Ciphers which stand in the three next places) placing the said Cube next after, to wit, on the right hand of the remainder; so the next Cube 464 being placed after the Remainder 32, there will be found the Number 32464, which may be called the Resolvend. Having drawn a Line under the Resolvend, square the Root in the Quotient, that is, mulitiply it by it self, and subscribe the Triple of the said Square or Product, under the Resolvend, in such manner, that the first place (to wit, the place of Unites) of the said triple Square, may stand directly under the third place (or Place of hundreds) in the Resolvend: So the Square of the Root 5 is 25, the Triple whereof is 75, which I subscribe under the Resolvend in such manner, that the Figure 5, which is in the first place, (to wit, the place of Unites) in the Triple Product 75, may stand under 4, which is seated in the third place of the Resolvend. Triple the Root or Number in the Quotient, and subscribe this Triple Number in such man-

ver that the firſt place thereof, (to wit, the place of Unites) may ſtand directly under the ſecond place (to wit, the place of Tens) in the Reſolvend: So the triple of the Root 5 is 15, which I ſubſcribe in ſuch manner, that the Figure 5, which is in the firſt place (to wit, the place of Unites) in the ſaid triple Number, doth ſtand directly under 6, which is ſeated in the ſecond place of the Reſolvend: The Triple Square of the Root, and the triple of the Root being placed one under the other as is directed, draw a Line underneath, and add them together in ſuch order as they are ſeated, and let the Sum be eſteemed as a Diviſor: So the Triple Square 75, and the triple Number 15 being added together, as they are ranked in the Work, the Sum will be 765 for a Diviſor: Let the whole Reſolvend, except the firſt place thereof towards the right hand, (to wit, the place of Unites) be eſteemed as a Dividend; then demanding how often the firſt Figure (towards the left hand) of the Diviſor is contained in the correſpondent part of the Dividend, and obſerving in that behalf the Rules before taught in Diviſion, write the Anſwer in the Quotient: So I ask how often 7 (the firſt Figure of the Diviſor towards the left hand) is contained in 32, (the correſpondent part of the Dividend placed above) the Anſwer will be 4, wherefore I write 4 in the Quotient: Having drawn another Line under the Work, multiply the triple Square before ſubſcribed by the Figure laſt placed in the Quotient, and ſubſcribe this Product under the ſaid triple Square, (to wit, Unites under Unites, Tens under tens, &c.) So 75 being multiplied by 4, the Product is 300, which I ſubſcribe under 75 (the Triple Square.) Multiply the Figure laſt placed in the Quotient, firſt by it ſelf, and then the Product by the triple Number before ſubſcribed; this done, ſubſcribe the laſt Product under the ſaid triple Number, (to wit, Unites under Unites, Tens under Tens, &c.) So 4 being ſquared or multiplied by it ſelf, the Product is 16, which being multiplied by the triple Number 15, the Product is 240, this therefore I ſubſcribe under the aforeſaid triple Number 15. Subſcribe the Cube of the Figure laſt placed in the Quotient, under the Reſolvend, in ſuch manner that the firſt place of this Cube, (to wit, the place of Unites) may ſtand under the place of Unites in the Reſolvend: So 64 being the Cube of 4, I write it under the Reſolvend

ſolvend 32464, in ſuch manner, that the Figure 4, which is in the place of Unites in the Cube 64, may ſtand under the Figure 4, which is ſeated in the place of Unites of the Reſolvend. Drawing yet another Line under the Work, add the three laſt Numbers together in the ſame order as they are ſeated, and ſubtract the Sum of them from the Reſolvend, placing the Remainder orderly underneath: So the Sum of the three laſt Numbers, as they are ranked in the Work, is 32464, which if you ſubtract out of the Reſolvend 32464, the Remainder is 0. Thus the whole Work being finiſhed, the Cube Root of 157464, (the Number propounded) is found to be 54.

Note 1. When the Sum of the three laſt Numbers before mentioned is greater than the Reſolvend, the Work is erroneous, and then you are to reform it by placing a leſſer Figure in the Quotient.

Note 2. For every one of the particular Cubes (diſtinguiſhed by the Points) except the firſt Cube on the left hand, a Reſolvend is to be ſet apart, by bringing down to the Remainder the next Cube. And as often as a Reſolvend is ſet apart, ſo often is a new Diviſor to be found, by adding the triple of all the Root in the Quotient (conſiſting of what Number of places ſoever) to the triple of the Square of ſuch Root, after they are orderly placed, according as is above-mentioned.

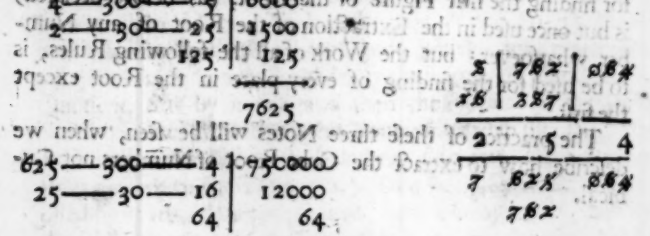
Note 3. The Work of the Table of Simple Cubes in Folio 9, for finding the firſt Figure of the Root, (as before declared) is but once uſed in the Extraction of the Root of any Number whatſoever; but the Work of all the following Rules, is to be uſed for the finding of every place in the Root except the firſt.

The practice of theſe three Notes will be ſeen, when we deſcribe how to extract the Cube Root of Numbers not Cubical.

CHAP. IX.

Another Example wrought by the Genitures.

Suppose a Number given to be 16387064, of which the Cube Root is required: First, you must cut the Cube given into Ternaries from the right hand to the left, (as was declared in *Chap.* 8.) Then find the Root of the first Cube from the left hand 16. Whereof the greatest Root is 2, for 2 being multiplied cubically, giveth 8, the which 8 being deducted from 16, the first Cube of the Number propounded, there remaineth 8; then set the Root found 2, with the Square thereof above it, and by the same the Geniture, and then find a second Figure for the Root of the second Cube, and you shall have 5, which ye shall set down with its Square and Cube under it, right against the Geniture towards the right hand, then multiply each one by another, and add the Products together, there cometh 7625, which being subtracted from 8387, there doth remain 762. In the same manner find a Root for the Numbers remaining to be extracted, and it shall be the Root of your third Cube; And the Example will stand thus.



And seeing there remaineth nothing, it is manifest that the Number propounded 16387064 is a Cube Number, and the

the Root thereof is 254. by the 4*th* Propoſition of the ſecond, and 20*th* Definition of the ſeventh Book of *Euclide*.

When we come to calculate the Table of Cubes, by which you may make an Inch Rule for height, or Line of Diameters, the way ſhall be deſcribed how to extract the Cube Root of Numbers not Cubical, or, as they are termed, Irrational Numbers, from which no true Root can be obtained, yet many times the Error will not be [illegible] part of an Unite.

CHAP. X

Principles of Geometry.

THere are divers Reaſons which make me to give theſe few Principles of Geometry, becauſe the whole Work of this Book, is either to be done by Arithmetick or Geometry; and beſides that a Gunner cannot obtain to know the truth of a Diameter of a Ball, except he can Geometrically extract the Wind of the Bore of the Piece, and thereby find the Ball fitting ſuch a Piece: And in general will be moſt uſeful for any Gunner.

Definitions.

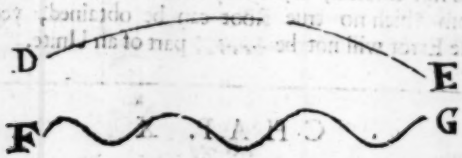
1. A Point or Prick, is that which is the leaſt of all Materials, and it is the beginning of Things, as being void of Length, Breadth, and Depth, having neither Part nor Quantity (expreſſible in Numbers,) and therefore it admits of no Diviſion, but that which is mental only. This Point or Prick is repreſented unto you by the Letter A. Thus A.

2. A Line is a Magnitude extending it ſelf in length, without breadth or thickneſs, (whether it be a ſtreight Line or crooked) and (in reſpect of its length) may be divided into Parts, but will admit of no other diviſion, but in length only. As is ſet forth to you by the Line B C; the extremities whereof being Points, as B and C.

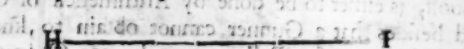
B ——————— C

3. A Right or Straight Line, is the nearest Distance that can be betwixt two Points; As in the former Line B C.

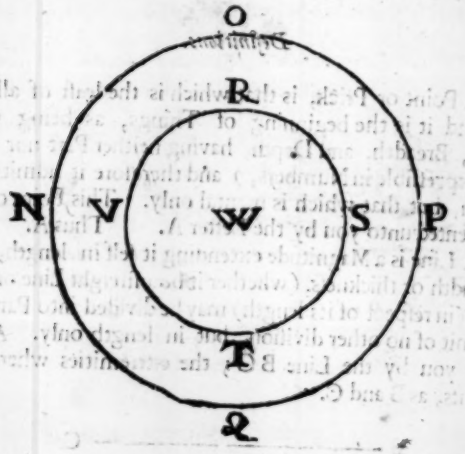
4. Circular or crooked Lines are longer, though they be extended no further than Right Lines, as are the Lines D E and F G.



5. Right-lined Parallels, are two straight Lines, so drawn, as they are equi-distant in all places one from the other; so that although they were infinitely extended, yet could they never meet; as may be seen by the Lines H I and K L.



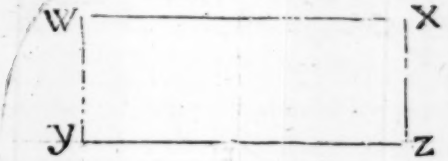
6. A Circular Parallel, is a Circle drawn either within or without another Circle, upon one and the same Centre, as is



seen

ſeen by the two Circles, *viz.* N O P Q and R S T V, being both drawn upon the ſame Centre W, and therefore are parallal one to another.

7. A Superfices is the ſecond kind of Quantity, and to it are attributed two Dimenſions, Length and Breadth, but not Thickneſs, for a Superfices is the term or end of a Body, as a Line is the end and term of a Superfices. As W X Y Z is a Superfices.

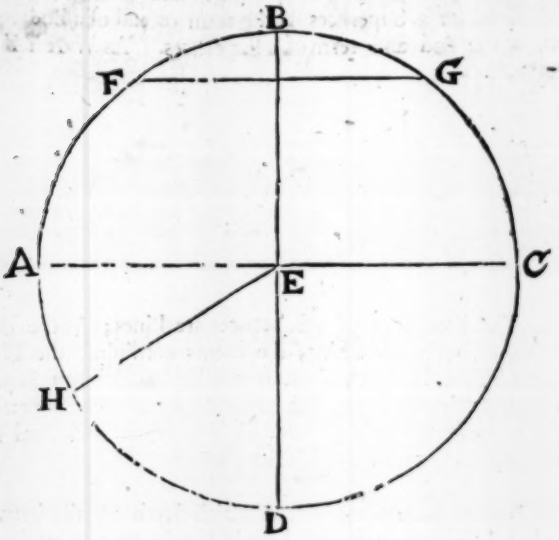


8. The Extreams of a Superfices are Lines; As the Ends, Limits, or Bounds of a Line, are Points confining the Line: ſo are Lines and Limits, Bounds and Ends incloſing a Superficies; As in the foregoing Figure you may ſee the Superficies incloſed with four Lines, *viz.* Y W, W X, X Z, and Y Z, which are the Extreams or Limits thereof.

9. A plain Superfices, is that which lyeth equally between his Lines, like as a Right Line is the ſhorteſt extention or draught from one Point to another; ſo a plain Superficies is the ſhorteſt extention or draught from one Line to another: As in the preceding Figure W X Y Z.

10. A Figure is that Magnitude comprehended by one Line, or more Lines than one: Under one Line is a Circle; Under more Lines is a Triangle, Quadrangle, Pentagon, Hexagon, and ſo forth.

11. A Circle is that Figure which is comprehended under one Line, called the Circumference, as A B C D; in the middle whereof there is a Point called the Centre, as E; from which, to the Circumference, all Lines being drawn, are equal; As in the ſaid Circle the Lines E A, E B, E C, and E D are equal.



12. The Diameter of a Circle, is a Right Line drawn through the Centre thereof, and ending at the Circumference on either ſide, dividing the Circle into two equal parts: As the Line A E C in this Circle is the Diameter thereof, becauſe it paſſeth from the Point A to the Point C, and ſo likewiſe through the Centre E, and divideth the whole Circle into two equal parts.

13. The Semi-diameter, being the half thereof; as A E and E C, the one Term whereof being the Centre, and the other the Circumference: It followeth by the *11th* Definition hereof, that all Lines drawn from the Centre to the Circumference are equal; Therefore is B E and E D likewiſe Semi-diameters.

14. A

14. A Semi-circle is a Figure which is contained under the Diameter, and under that part of the Circumference which is cut off by the Diameter, as the Semi-circle A B C, is contained under the Diameter A C, and alſo under the part of the Circumference A B C, which is cut off by the Diameter A C.

15. A Quadrant is the fourth part of a Circle, or is contained under two Semi-diameters, and the fourth part of the Circumference, as in the preceding Circle A E B or B E C.

16. A Segment of a Circle, is a part of the Circle contained under a Chord-Line, (not being the Diameter) and a part of the Circumference, as F B G being the leſſer Segment; and the Remainder to the whole Circle being the greater.

17. A right-lined Angle, is the Inclination, or bowing of one Line to another; which being extended, do concur or meet in a Point, as in the preceding Circle A E B or A E H, &c. the middle Letter ſignifying always the Angle, as E.

18. Of Right-lined Angles there be three kinds, *viz.* A Right-Angle, an Obtuſe or Blunt-Angle, and an Acute or Sharp-Angle.

19. A Right-Angle is that, when one Line falling upon another maketh the Angles on both ſides equal, then either of thoſe Angles is a Right-Angle: and the Right Line which ſtandeth erected, is called a Perpendicular Line to that upon which it ſtandeth. As upon the Right-Line A C, ſuppoſe there do ſtand another Line B E, (as in the preceding Circle) in ſuch ſort, that it maketh the Angles on either ſide thereof equal, namely the Angle A E B on the one ſide, equal to the Angle B E C on the other ſide, then are each of thoſe Angles Right-Angles, and the Line B E, which ſtandeth erected on the Line A C, is a perpendicular to the ſaid Line A C.

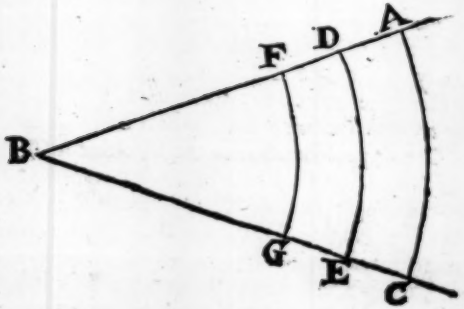
20. An Obtuſe-Angle is that which is greater than a Right-Angle, as the Angle H E B (in the preceeding Circle) is greater than the Angle A E B, by the Angle A E H, and therefore is an Obtuſe-Angle.

21. An Acute or Sharp-Angle, is that which is leſs than a Right-Angle, as the Angle A E H is an Acute-Angle, becauſe it is leſs than the Right-Angle A E D, by the other Acute-Angle D E H.

Obſ. 1. Here you are to obſerve, That the Circumference of every Circle doth differ from the Circle, as that which is contained doth differ from that which containeth.

Obſ. 2. The Circumference of every Circle, is underſtood to be divided into 360 Parts, called Degrees; and every one of theſe into 60 other Parts, called Minutes; or into 100 Parts, called Centeſms: But the Reaſon of this Diviſion may be demanded, Wherefore into 360, and into no other Number, did the firſt Artiſts divide every Circumference? I Anſwer, That only Magnitude being to be divided into certain parts, the ſame ought to be divided into the leaſt and beſt, for dividing as in equal parts: But ſo it was, that no Number under 360 could be had, as being diviſible into more equal parts; and likewiſe being a Number not very troubleſome to the Memory. Therefore not without Cauſe or Reaſon they made choice of that Number before any greater or leſſer.

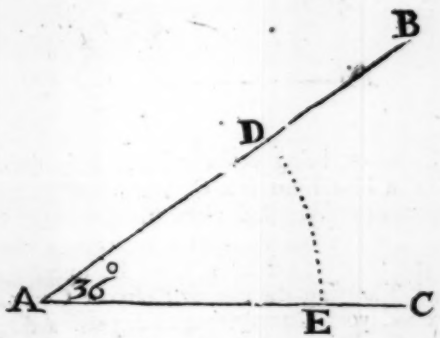
Obſ. 3. From an Arch of the Circumference is taken the Meaſure or Quantity of all Angles; for the Quantity of an Angle, is an Arch or Ark of the Circumference, deſcribed from the Angular Point, and contained betwixt the two Lines forming the Angle. As the Arches F G, D E, A C, deſcribed from the Angular Point B: So that ſo many Degrees as are contained in theſe Arches, ſuch is the quantity of the Angle A B C.



I ſay all theſe Arches being equal; not according to quantity of extenſion: for certain it is that F G will be leſſer than A C; But

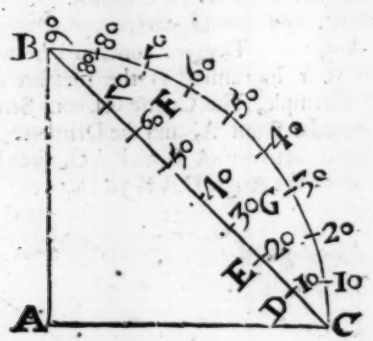
but I ſay that they are equal according to the number of Parts, for there are more Parts in the Arch A C than in F G, although the quantity of the one be greater than the quantity of the other; becauſe all Circles deſcribed from the ſame Centre are equal, all being divided into 360 Degrees.

From hence it follows that every Angle may be meaſured by an Arch of a Circle actually divided; whether it be Semi-circle, Quadrant, or Line of Chords, (the conſtruction of which hereafter followeth;) And firſt by a Semi-circle divided into 180 Degrees: Firſt, Lay the Centre of the ſame upon the Angular Point, and the Diameter upon one of the Lines forming the Angle, the Degrees contained between theſe two Lines upon your Inſtrument is the meaſure of your Angle. As in this Example, The Centre of your Semi-circle placed upon the Angular Point A, and the Diameter upon A C, the Arch contained between A B and A C, ſuch is D E, which is the meaſure of the Angle D A E 36 Degrees.



22. The meaſure of any Right-lined Angle, may be had by a Line of Chords, which is deſcribed upon a Ruler; which Line is virtually the Arch of a Circle; The Projection wherof is as followeth. Let there be a Quadrant, or fourth part of a Circle, as B A C, divided into 90 Degrees; Firſt, Into three parts, each containing 30 Degrees, by taking the Semi-diameter, as A B, with your Compaſſes; place one foot

in C, and with the ſame wideneſs ſet the other foot in F; ſet again the one foot of your Compaſſes in B, (the Compaſſes not being altered) and with the other take the extent B G: So your Quadrant ſhall be divided into three equal parts, *viz.* C G 30 Degrees, C F 60, and the reſt unto B 90 degrees: Every one of theſe being again ſubdivided into three equal parts; ſo ſhall you have the Quadrant divided into nine parts, or 90 degrees, each part containing ten degrees: and ſo into ſmall parts according to the largeneſs of your Quadrant.

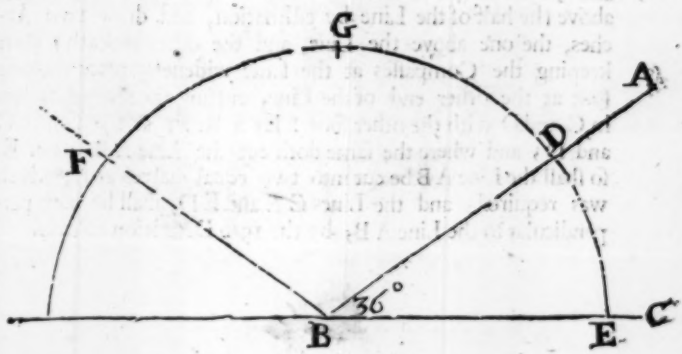


The Quadrant being performed and truly divided; you ſhall draw a Line from B to C, which ſhall be the Chord of 90 degrees; again you ſhall place the one foot of your Compaſſes at C, and extend the other to 10 degrees; the ſame extention you ſhall lay off from C to D, upon the Line of Chords, ſtill keeping the one foot of your Compaſſes at C; again extend your Compaſſes to 20 degrees, and lay them off from C to E; and ſo accordingly to all the reſt, till you have finiſhed the diviſion of your Line. Which being performed, ſhall ſerve you to meaſure the quantity of all Right-lined Angles, as well as by any Circular Arch; being more portable, and more ready for uſe, than any Circular Inſtrument, as Semi-Circle, Quadrant, *&c.* as by the following practice is evident.

The

The Uſe of the Line of Chords.

23. Let there be an Angle, as A B C, whoſe quantity is deſired: The ſame is performed by a Line of Chords; if you place the one foot of your Compaſſes at the end of your Line, and the other upon 60 degrees; then the Compaſſes remaining at the ſame wideneſs, place the one foot at B, and draw an Arch as D E; whoſe wideneſs you ſhall take by your Compaſſes, and apply the ſame to your Scale upon the Line of Chords, you ſhall have the quantity of the Angle 36 degrees.



But if the Angle be obtuſe or blunt, as F B C, extend the Compaſſes upon your Scale to 60 degrees, drawing an Arch from the Angular Point; then firſt take off 90 degrees from your Line of Chords, and place the ſame from E to G, the remainder being taken from G to F, the diſtance whereof is 54 degrees; which two Arches being added together, ſhall give the quantity of the Angle F B C, reckoned 144 degrees. And thus much for finding the quantity of all Right-lined Angles, by the Line of Chords upon your Scale.

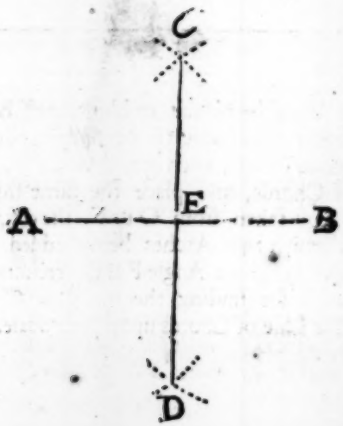
CHAP.

CHAP. XI.

Geometrical Problems.

To divide a Line given into two equal Parts at Right-Angles.

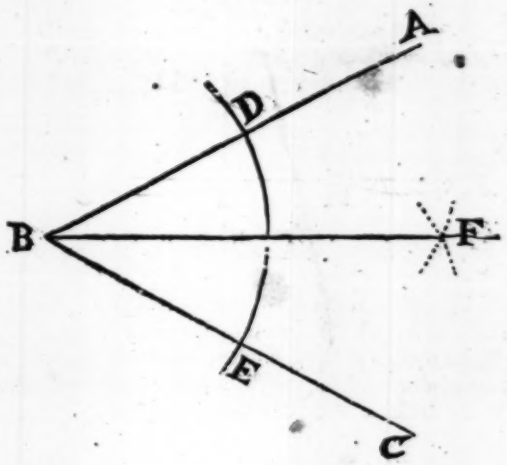
Prob. 1. LEt the Line given be A B; having placed the one foot of your Compaſſes at A or B; extend the other at pleaſure, above the half of the Line by eſtimation, and draw two Arches, the one above the Line, and the other beneath; then keeping the Compaſſes at the ſame wideneſs, place the one foot at the other end of the Line, cutting the former Arches in C and D with the other foot: lay a Ruler at the points C and D; and where the ſame doth cut the Line A B, as in E, ſo ſhall the Line A B be cut into two equal halves at E, which was required; and the Lines C E and E D, ſhall be both perpendicular to the Line A B, by the 19*th* Definition of this.



An

An Angle being given, to divide the ſame into two halves.

Let the Angle be A B C, to be divided into two equal halves: Place the one foot of your Compaſſes at B, and extend the other at your pleaſure to D and E; deſcribe two Arches cutting each other in the point F: So ſhall you divide the Angle A B C into two equal halves, if you draw a Line from B to F, with two Angles A B F, and F B C, as equal to the whole Angle A B C, being divided into two halves. *Prob.* 2.

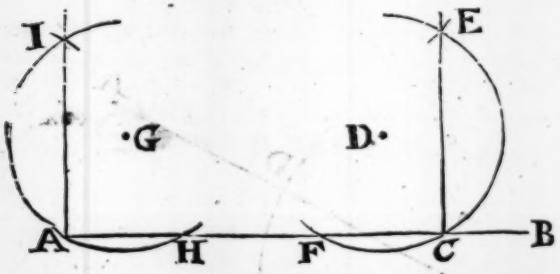


From

From any Point, or from the end of a Line, to erect or raiſe a Perpendicular.

Prob. 3. Let there be given the Line A B, and the Point in the ſame given C, from which a Perpendicular is to be raiſed.

Place the one foot of your Compaſſes at C, and with the other take at pleaſure above the Line, as D; then from the point D, deſcribe the Arch of a Circle, as E C F, cutting the Line A B in F; then lay your Ruler at F and D, and where it cutteth the Arch as in E, draw a Line from C to E, which ſhall be Perpendicular to A B, from the point C.



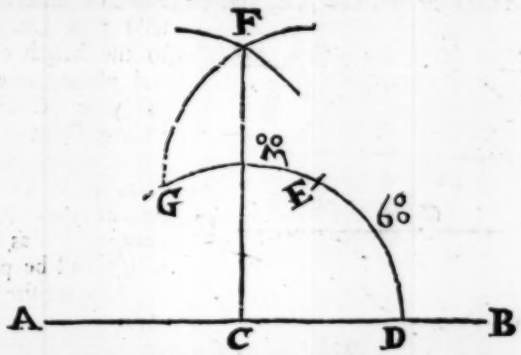
Again, from the point A, a Perpendicular is raiſed the ſame manner of way; placing one foot of your Compaſſes at A, extend the other above the Line to the Point G; and draw from G the Arch I A H, cutting the Line at H; then laying your Ruler by G and H, and where it cutteth the Arch as in I; from A to I draw a Line, ſo ſhall A I be a perpendicular from the end of the Line A B, or from the point A.

The ſame may be performed by the Line of Chords, as by the practice is evident.

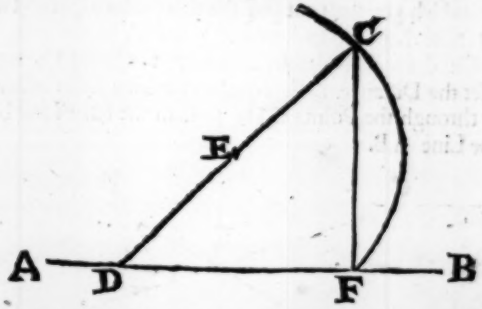
The

The ſame another way.

A Perpendicular may be raiſed after this manner; As let the Line be A B; and a Point in the ſame Line given, let be C: place the one foot of the Compaſſes at C, and with the other draw an Arch above a Quadrant, as G E D; then place the diſtance of C D from D to E; then placing the one foot at E, draw the Arch G F; then removing your Compaſſes, place the one foot at G, and with the other cut the Arch in F: Laſtly, From E to C, draw a Line F C; ſo ſhall F C be a Perpendicular from the point C.



From a Point without a Line, to let fall a Perpendicular to a Line given.

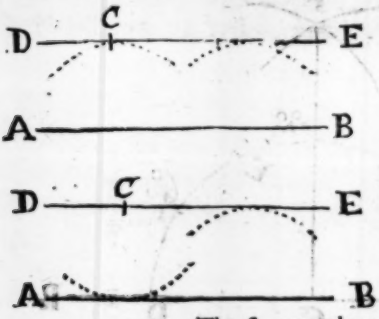


Let the Line given be A B, and the Point without the ſame at C: Draw a Line to A B at Oblique Angles, as C D; which *Prob.* 4.

you ſhall cut (by the firſt Problem) in two halves at E; then place the one foot of your Compaſſes at E, extend the other unto C, drawing the Arch C F: and where the ſame cutteth the Line A B, as in F, from C to F draw a Line, as C F; ſo ſhall C F be a Perpendicular let fall from the Point C, upon the Line A B, as was required.

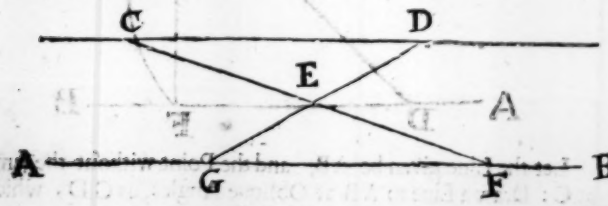
A Line being given, to draw a Parallel to the ſame, at any diſtance required.

Prob. 5. Let the Line given be A B, and the Diſtance from C: Extend your Compaſſes to the length of C, and placing one foot of your Compaſſes in any Point of the Line, draw two Arches; and by the Compaſs of theſe Arches, draw a Line as D E; which ſhall be parallel to A B required; as C E.



The ſame another way.

Let the Line given be A B, and the Point at C: From the Point C, draw a Line at pleaſure unto A B, which ſhall touch in F, which you ſhall cut (by the firſt Problem) into two halves at E: take then a Point betwixt F and A at pleaſure, which is here G: draw then a right Line from the Point G, through E, and ſet the Diſtance D E, equal to the Line E G: draw then a Line through the Points G D; ſo ſhall the ſame Line be parallel to the Line A B.

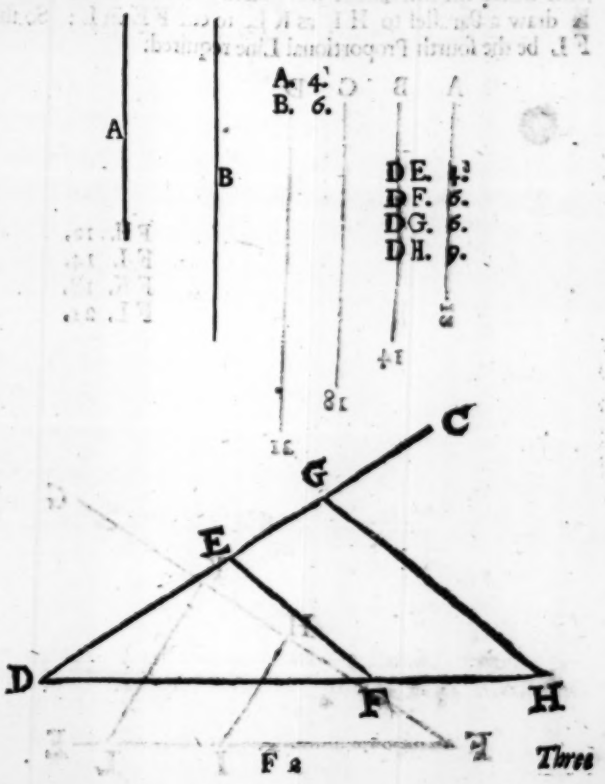


Two

Two Lines being given, to find a third proportional Line.

Let A and B be two Lines given, and let it be requited to find a third Line in proportion to them. *Prob.* 6.

First, Make any Angle, as C D H; then set the Line A from D to E, and the Line B from D to F, and also from D to G; then draw E F: that done, by the Point G draw a parallel to E F, and G H: So shall D H, be the third proportional Line required.

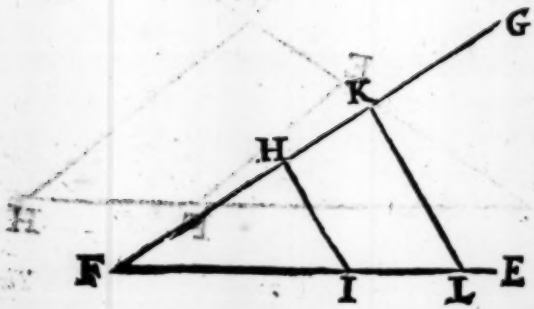


Three Lines being given, to find a fourth in proportion, that is to perform the Rule of Three in Lines.

Prob. 7. Let A B and C be three Lines given, and it is required to find a fourth proportional Line.

First, (as in the laſt Problem) make any Angle at Pleaſure, as the Angle E F G; Then take with your Compaſſes the Line A, and ſet it from F to H; take alſo the Line B, and ſet it from F to I, and draw the Line H I: That done, take the third Line C, and ſet it upon the Line F G, *viz.* (always upon the ſame Line where the firſt Line A was placed) from F to K; then by K draw a Parallel to H I, as K L, to cut F E in L: So ſhall F L be the fourth Proportional Line required.

F H. 12.
F I. 14.
F K. 18.
F L. 21.

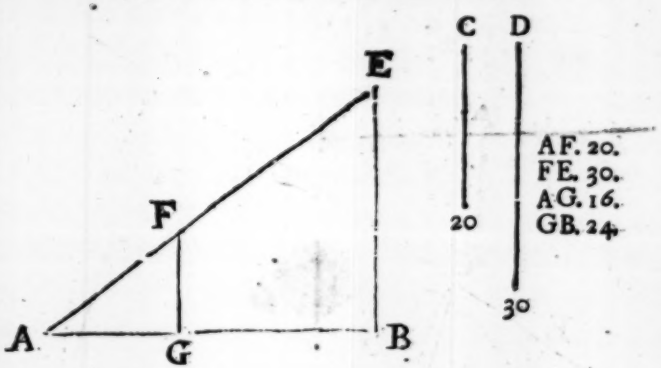


To

To divide a Line given into two parts, in proportion one to the other, according to two Lines given.

Let A B be a Line given, to be divided into two such parts, that the lesser may be in proportion to the greater: As the Line C, to the Line D. *Prob.* 8.

From the end A draw the Line A E, making the Angle B A E: then set the Line C from A to F, and the Line D from F to E, and draw the Line E B: Lastly, By the Point F draw a Parallel to E B, as F G, to cut A B in G: So shall A B be divided in G, as C to D, which was required.



To cut off from a Line given any part or parts required.

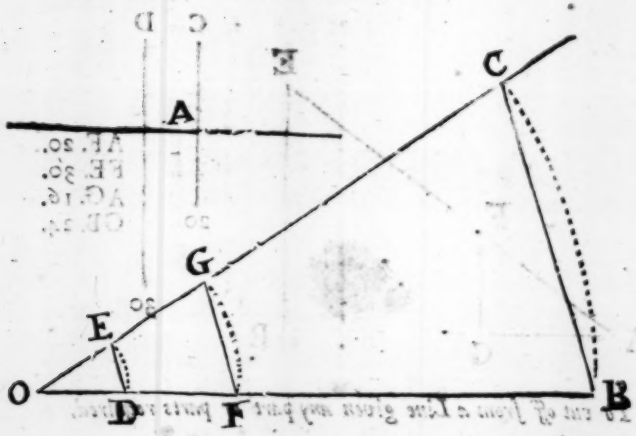
Let in the last Diagram A B be a Line given, and let it be required to cut off from it $\frac{2}{5}$ parts. *Prob.* 9.

First, From the end A, draw the Line A E, making any Angle as B A E; then set on any five equal parts from A to E, and also two of the same parts from A to F: That done, draw the Line E B; then by F draw a Parallel thereunto, to cut A B in G: So shall A G be the $\frac{2}{5}$ parts of A B, which was required.

To

To divide a Line in such sort, as another Line is before divided.

Prob. 10. This Problem differeth not much from the two last Problems. Draw a Right Line at pleasure, as the Line O B, which Line you shall divide into 100 equal parts as exactly as you can; then extend your Compasses to the Distance O B, and describe an Arch; in which Arch you are to include the desired Line A; then draw the Line O C, and you have the Angle C O B: which we shall hold for a ground-Rule; because the Legs O B and O C, contain each of them 100 or 1000 parts, which is in the Line A.



For Example.

I would have 35 parts of the Line A, (whose whole length making 100 parts, as the Line O B doth): I number on the Line O B, 35 parts from O to F; with this distance I draw the Arch E G; then, is the neareſt Distance from E to G, a Right Line, which is the 35 parts of the Line A.

Likewise if it were desired to have 15 parts of the Line A: Then draw from O the Arch E D; which Distance is the desired 15 parts of the Line A; as the Learned *Adriani Metii* doth

doth teach. And alſo how to find the Parts of a longer Line, than the Line of Meaſure it ſelf is; it is done after the ſame manner; and is of great uſe to a Gunner.

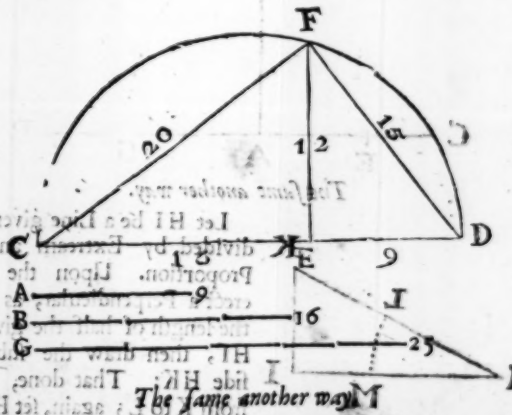
Uſe.

This may be of great uſe, if the Gunner be to find the firſt Pound Ball in a ſtrange place, and the Weight unequal to Ours.

Between two Lines given, to find a mean proportion.

Let A and B be two Lines given, between the which it is required to find a mean Proportion. *Prob.* 11.

Join the Lines A and B to together, that they make one Right Line as C D, being joined together in the Point E: and upon the Line C D deſcribe the Semi-circle, *viz.* C F D: Then upon the Point E, where the Lines A and B being joined together meet, erect a Perpendicular to cut the Limb in E, as E F, which ſhall be a mean Proportion between the Lines A and B required.



The ſame another way.

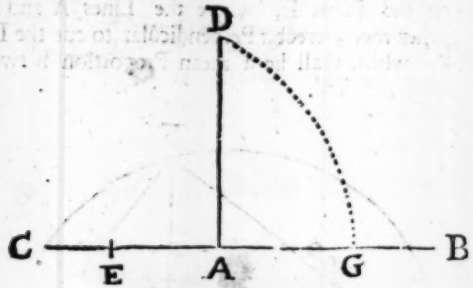
Again in the ſame Diagram, let the Lines A and G be given, between the which it is required to find a mean Proportion.

Take

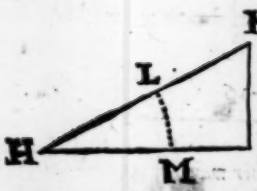
Take the Line G, and lay it down from C to D, and draw C D; whereupon describe the Semi-circle C F D: Then take the Line A, and set it from D to E; Then upon the Point E, erect a Perpendicular to cut the Limb in F; Lastly, Draw D F, which shall be a mean Proportion between D E and D C, or between the Lines A and G required. And if you draw C F, it shall be a mean between B and G, that is, between C E and C D.

To divide a Line given by Extream and Mean Proportion.

Prob. 12. Let A B be a Line given to be divided by Extream and Mean Proportion. Increase A B at length to C; then upon the Point A erect a Perpendicular as A D, of the length of A B: That done, take half A D, or A B, and set it from A to E, then with the distance E D make the Arch D G: So shall A B be divided by Extream and Mean Proportion in G, and A G is the greater Segment, and G B the lesser.



The same another way.

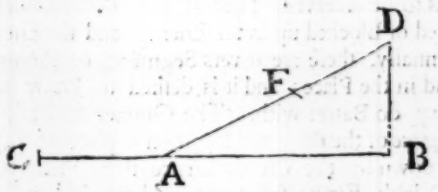


Let H I be a Line given, to be divided by Extream and Mean Proportion. Upon the end I, erect a Perpendicular, as I K, of the length of half the given Line H I; then draw the subtendant side H K: That done, set K I from K to L; again, set H L from H to M; so shall H I be divided by Extream and Mean Proportion in M: And H M shall be the greater Segment, and M I the lesser.

The

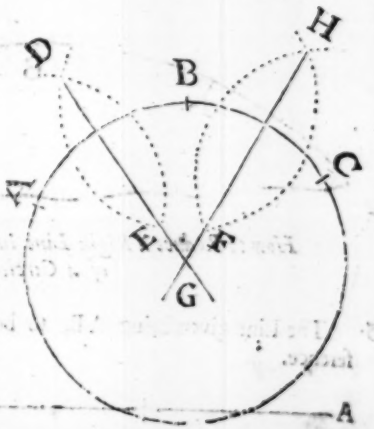
The greater Segment of a Line divided by Extream and Mean Proportion, to find the whole Line.

Let A B be the greater Segment given, and the whole Line is required. Increaſe B A to C; then upon the end B erect a Perpendicular of half the length of A B, as B D; and draw the ſubtendant ſide A D; from which ſubtract D B, reſts A F: That done, ſet A F from A to C; ſo ſhall C B be the whole Line required. *Prob.* 13.



To deſcribe a Circle upon any three Points given, not being in a Right Line.

Let A B C be three Points given. Set one foot of the Compaſſes in the middle Point at B, and open your Compaſſes to any extention that is above one half of the diſtance between B, and the fartheſt of the other two Points, and with that diſtance draw the blind Arches D E and F H: with the ſame extent ſet one foot in C, draw the Arch F H: Again with the ſame extent, ſetting one foot in the Point A, draw the Arch D E: then laying a Ruler to the Interſection of theſe Arches, draw the Lines D G and H G; which *Prob.* 14.



G

which will croſs each other in the Point G: and there is the Center of the Circle inquired. Where ſetting one foot of your Compaſſes, and extending the other to any of the three Points, you deſcribe the Arch of a Circle, which ſhall paſs through the three Points given, and give the whole Circumference required: which having, you may find the Diameter by the 12*th* Definition of *Chap.* 10. of this Book.

Obſervation.

By a Segment, or a piece of a Ball being found, to know the weight of the whole Ball.

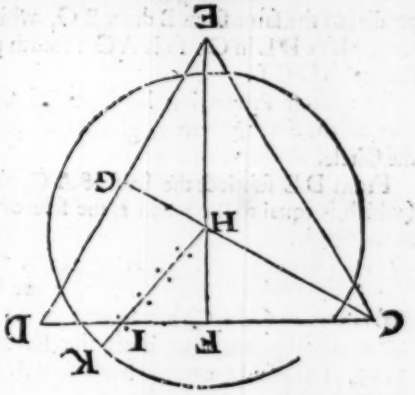
Here is to be obſerved, That if any Town, Fort or Place be Beſieged or Blocked up by an Enemy, and the Enemy ſhooting continnally, there are divers Segments or Pieces of their Ball found in the Place; and it is deſired to know what Ordnance they do Batter with. The Gunner ſhall take the Segment or piece of the Ball, and lay it on a piece of Paper, and ſet there down by the Circumference three Pricks or Points, as A B C in the Figure following, and thereby, and by the preceding Problem, ſhall find the Diameter, Center, and Circumference of the Ball, whereby you may know the weight of that Ball; as is deſcribed in *pag.* 54.

How to Reduce a Right Line into the Circumference of a Circle.

Prob. 15. The Line given being A B, to be reduced into a Circumference.

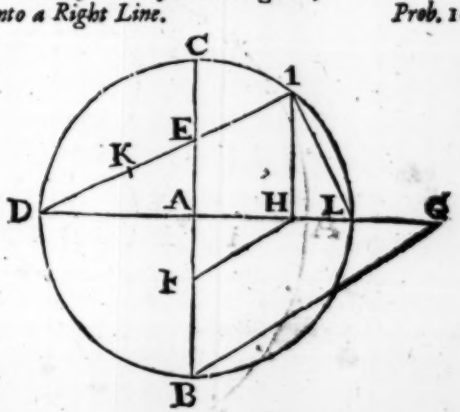
The which Line A B, you ſhall firſt divide into three equal parts, and of theſe three Parts you ſhall make an Equilateral Triangle,

Triangle, as C D E; the half of C D is F, and the half of the ſide D E is G; and where they cut one another as in H, that is the Center of the Triangle CDE: further divide D F into halves with the point I; draw then a right Line from the Center H to I, which is H K; and divide the Line H I into four equal parts, of which you ſhall add one part unto H I, which ſhall be H K, (which is the ſame fourth part five times ſet); ſet then one foot of your Compaſſes in the point H, and the other in the point K; and draw with the ſame diſtance a round Circle, whoſe Circumference ſhall be equal to the Line given, *viz.* the Line A B, which was required.



How to reduce the Circumference of a Circle given, into a Right Line. *Prob. 16.*

Let the Circle given be A B C D. Divide the ſame Circle in four equal parts with the two Diameters B C, and D L, which cutteth one another at Right Angles in A; divide A C in the middle in E, through the which draw D I, and from I draw a Perpendicular upon D L, and divide A B in Extream and Mean Proportion at F, (by Problem 12 of this) draw F H, and



parallel to the ſame from B draw B G, which cutteth the prolonged Line D L in G; ſo is A G a fourth part of the Circumference B D C L.

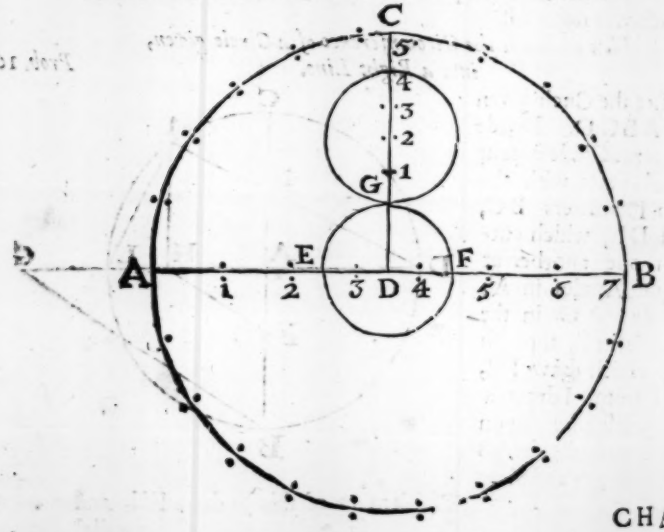
The Mean Proportion betwixt D L and A G, the fourth part of the Circumference, giveth the ſide of a Square equal to the Circle.

From D E ſubtract the half of A C, there remaineth D K, (which is equal to B F) and is the ſide of a *Decagon* inſcribed in the Circle.

The Diameter of a Circle being given, to find its Proportion to the Circumference, or the Reverſe.

Prob. 17. *The true knowledg of this Problem is of great uſe for Gunners, both by Sea and Land.*

Whenſoever the Circumference of a Circle is divided into 10000 equal parts, then doth the Diameter thereof contain 3183 of the ſaid parts, ſaith *Adriani Meti.* But *Archimedes* ſheweth us the eaſieſt and fitteſt for our purpoſe; to wit, That if the Circumference be divided into 22 equal parts, then the Diameter doth contain ſeven of the like parts: as is demonſtrated in this Figure, where you may ſee, that in the Circle A B C, the Circumference is divided into 22 equal parts, and the Diameter A B doth contain ſeven of the ſame parts.



CHAP.

A Light to the Art of Gunnery.

CHAP. XII.

How to know the Proportion of a true Fortified Iron Gun.

BY the Demonſtration of the laſt Problem, you have the the proportion of a true Fortified Iron Peece; for a true Fortified Peece of Ordnance being of Iron, hath 11 Diameters of the Bore about the Breech, meaſuring at the Touch-hole betwixt the Rings; which to deſcribe is thus.

In the Diagram of the 17*th* Problem, the Diameter being divided into 7 equal parts, as is the Diameter A B; then take with your Compaſſes one of the ſame parts, and ſet one foot in the Center, and with the other draw the Circle E G F, then ſhall the Line E F be the Diameter of the Bore of that Peece of Ordnance, and the Circle A C B, the Circumference of the Breech of the ſame Peece at the Touch-hole: where it followeth that one 22 part of a well-proportioned Peece of Ordnance made of Iron, meaſured about the Breech, is half the Diameter of the Bore of the ſame Peece; the which is 11 Diameters of the Bore, as aforeſaid: And therefore one ſide Metal, or the thickneſs of Metal at the Touch-hole is 1¼ Diameter of the Bore, as appeareth from G to C, which is compleatly demonſtrated by the ſaid Diagram of the 17*th* Problem: Alſo by the Neck, near the Muzzle of the Gun, are ſeven Diameters of the Bore about; which is near ⅞ parts of the Diameter in Metal.

The true proportion of a Gun.

If you ſhould take the Diameter of the Breech of this Peece ſeven times to be the length of the Peece, and allow three of thoſe parts betwixt the Breech and the Meeks, or Trunions, and four of theſe parts betwixt the Meeks and the Muzzle of the ſaid Peece, then that Peece hath her true proportion.

The

The Reaſon why one Gun muſt have more, and another leſs Powder.

Tho there are many Guns that are ſome ſhorter, and ſome longer, yet they ought not to be thinner of Metal; for if they be thinner, then they are not able to have their true proportion of Powder, either for Proof or Action: Likewiſe know that true Fortified Guns, and true Bored Braſs Ordnance, be their Denomination what it will, ought to have at the leaſt 9 Diameters of the Bore about the Breech, meaſuring at the Touch-hole, and at the Meeks 7 Diameters of the Bore, and 5 Diameters about the Muzzle at the Neck: if they have leſs than is above-ſaid, they cannot ſuffer their true proportion of Powder, either for Proof or Action: But this you muſt help, by what ſhall be fully deſcribed in its proper place.

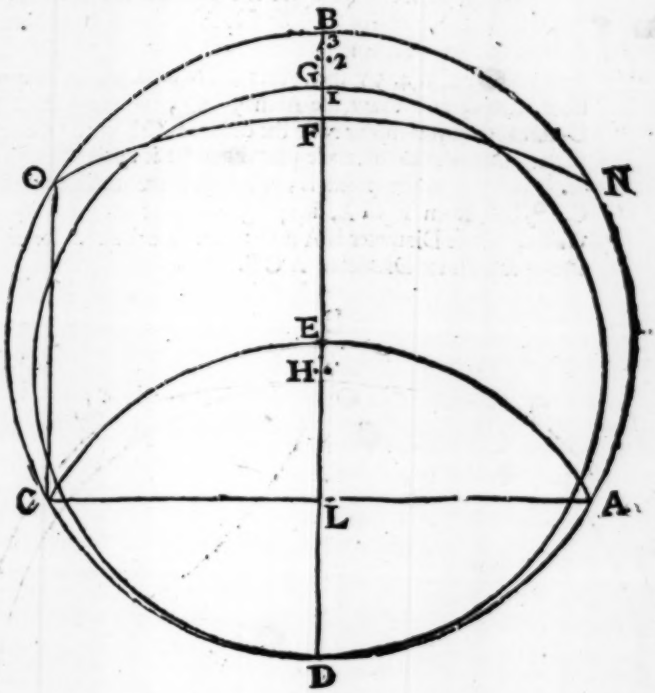
CHAP. XIII.

How to Extract the Wind from the Bore of a Peece Geometrically, and thereby to know a fit Ball for the ſame.

A good way to find the Wind of a Peece of Ordnance under four pound Ball.

First, You are to draw the Diameter of the Bore B D, and that Line you are to divide into two equal halves, as E B and E D; then you have the Center E, by which you draw the Circle A D C B: Which being done, with your Compaſſes at the ſame extent draw an Arch from the Point D, extended to A E C; then draw the Chord-Line A L C; keeping ſtill your Compaſſes at the ſame extent, meaſure from A to D, then to C, and ſo to O: then extend your Compaſſes from D to O, and draw the Arch O N, which cutteth the Diameter in F: then divide the Line F B into three equal parts, and take one of theſe parts and place under the Center E in H, extend your Compaſſes from H to D, and draw the Circle, whoſe Diameter is D G, and is the Ball fitting for ſuch

ſuch a Peece, where you are to obſerve that G B is the Height of the Wind of the Peece.



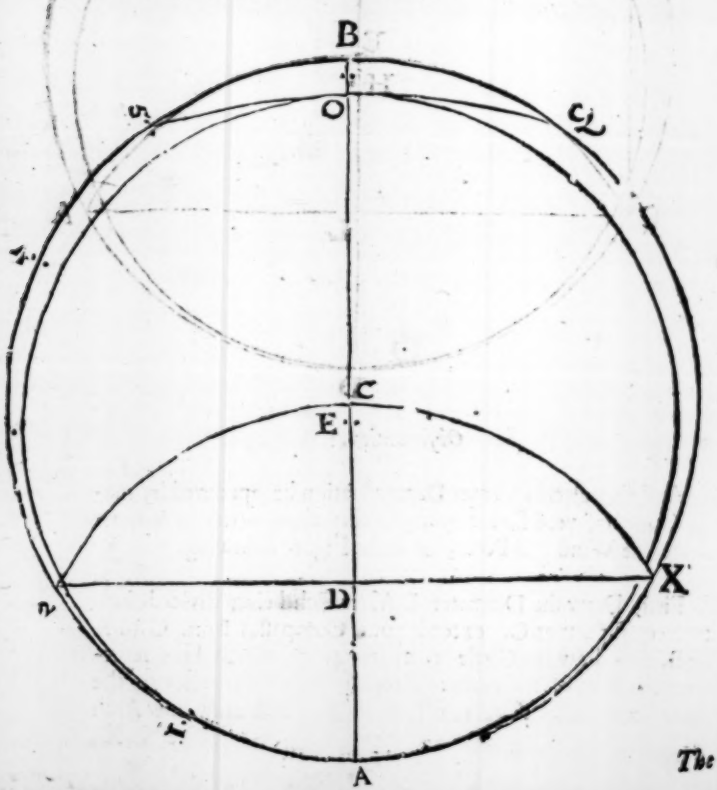
Obſervation.

And though this former Demonſtration be approved by many Gunners, yet I find it by my Obſervation, better to demonſtrate the Wind of a Peece, as in the Figure following.

Firſt, Draw the Diameter B A, which being divided into two equal parts at C, extend your Compaſſes from C to A or B, and draw the Circle 1. 2. 3. 4. 5, which here repreſents the Bore of the Peece: Keeping your Compaſſes at the ſame extention, place one foot in A, and draw the Arch 2, C, X;

A true way to Extract the Wind of a Peece of Ordnance, and thereby to find her true Ball.

2, C, X; then drawing the Chord-Line 2, X, it divides the Semi-diameter of the Bore into two equal parts; then you are to extend your Compasses to the distance A D, or D C: So fixing one foot of your Compasses in A, you are to measure five of these Dimensions about the Circle, as you see them described, 1. 2. 3. 4. 5; then you must extend your Compasses from A to 5, and draw the Arch 5, Q, whereof A is the Center; then you must divide the distance O B into two equal parts, and take one of these parts, and set it upon the Diameter below C in the point E; then you are to extend your Compasses from E to A, keeping one foot in E, draw the Circle, whose Diameter is A E O: and is a Ball fit for such a Peece as hath for Diameter A C B.

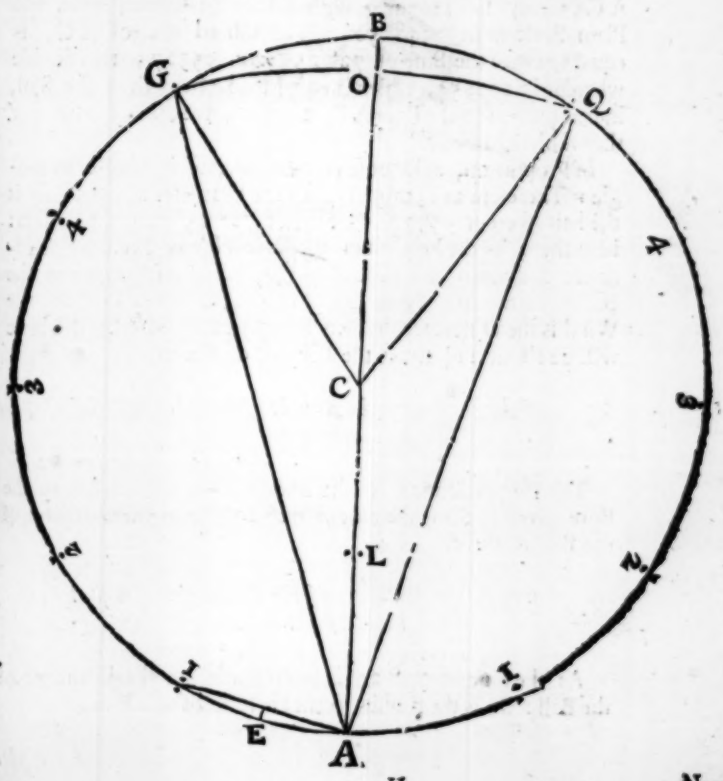


The

The ſame by Calculation.

In the following Diagram A B, the height of the Bore of a Peece being given, to find the Diameter of the Ball A O.

Firſt, Take the Semi-Radius A L, and ſet it off in the Circumference from A towards B five times, as you ſee here marked with 1. 2. 3. 4. G; or 1. 2. 3. 4. Q: then extend your Compaſſes from A to G, and draw the Arch G O Q, ſo is A O the Diameter of the Ball, and B O the Wind.



Now

Now to find this by Calculation, First, consider that A G or A Q is equal to A O, and A 1 equal to A L; then A L being the Semi-Radius 50000, is equal to the Chord A 1, withal considering that the Chord of an Arch is equal to double the Sine of half that Arch; Now then 25000 the half of A L is the Sine A E, which in the Table of Natural Sines, giveth 14° 29′, for the Arch A E, the double whereof giveth 28° 58′, for the quantity of the Arch A 1, which being quintupled, or multiplied by 5, giveth 144° 50′ for the Arch A G or A Q, so that the Arch G B Q is 70° 20′: The Angle A C G may be measured with a Line of Chords from the Plain Scale to be 144° 50′. The Chord whereof A G, is equal to twice the Sine of 72° 25′, *viz.* 95327; the double whereof is 190654, which is equal to the heighth of the Ball, in comparison to the Bore A B, 200000, twice the Radius, or the whole Diameter.

In Proportion, as Double is to Double, so is Single to Single: Therefore as 190654 is unto the Diameter 200000, so is the half thereof 95327, the Sine of 72° 25′ unto the Radius: I say then, if the heighth of the Bore of any Peece of Ordnance be divided into 100000 parts, then the Diameter of the Ball is for the same Peece 95327 of the same parts; and the Wind is the Difference, which is 4673 parts, so that the Bore will be about 21$\frac{1}{2}$ times the heighth of the Wind.

If the heighth of the Bore be given, to find the Diameter of the Ball.

The Proportion is: As the Radius is to the heighth of the Bore given: So is the Sine of 72° 25′, unto the Diameter of the Ball required.

Or, if the Diameter of the Ball be given, to find the Bore: Say then,

As the Sine of 72° 25′ is in Proportion to the Diameter of the Ball: So is the Radius to the Heighth of the Bore.

Example.

Example 1.

I have an Iron Ball whoſe Diameter is four Inches, and weigheth 9 ℔ Engliſh Weight, and I deſire to know what heighth the Bore of the Peece will be, which this Ball ſhall fit, the Wind duly extracted.

Sine of 72° 25′	Inches	Radius
95327	4	100000
		4
		400000

95327) 400000 (4 19
381308
186920
95327
915930
857943
57987

I Anſwer, The Heighth of the Bore of ſuch a Peece of Ordnance is 4 Inches and $\frac{19}{20}$ part *ferè*.

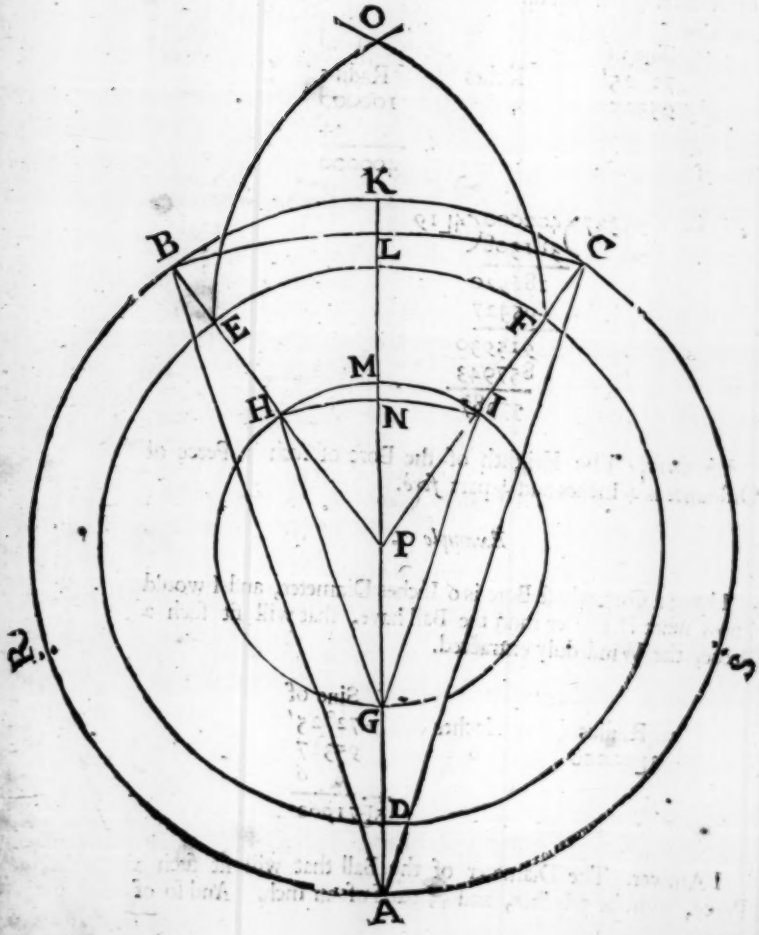
Example 2.

I have a Gun whoſe Bore is 6 Inches Diameter, and I would know what Diameter muſt the Ball have, that will fit ſuch a Peece, the Wind duly extracted.

Radius	Inches	Sine of 72° 25′
100000	6	95327
		6
		571962

I Anſwer, The Diameter of the Ball that will fit ſuch a Peece, muſt be 5 Inches, and $\frac{71962}{100000}$ parts of an Inch. And ſo of others.

Another way to Extract the Wind of a Gun, as well Geometrically as by Calculation.



The

The Height of the Bore of any Peece of Ordnance being given, as the Bore A K or G M (in the preceding Diagram) to find the Diameter of the Ball: First, With 60° of the Line of Chords, I draw the Circle D E F; then with 72° of the ſame Line, I draw the Arches E O and O F, which do meet in the Point O: From O through the Center P, I draw the Diameter K A: Then from the Center P, I draw Right Lines through the Points E and F, which do cut the Circle A K in B and C, and the Circle G M in H and I: So that B C is 72° of the Circle K A, and H I is 72° of the Circle G M, as well as E F is of the Circle D E F: then extend the Compaſſes from A to B, ſetting one foot in A, with the other draw the Arch B L C; ſo is A L the Diameter of a Ball for the Bore A K: Or from G to H, ſetting one foot in G, with the other draw the Arch H N I; ſo is G N the Diameter of a Ball for the Bore G M: Or otherwiſe, not having a Line of Chords to meaſure 72°, upon the Circumference of the Bore given: As here in the Bore A K, divide the Circumference of thr Bore into five equal parts, as B C S A R, and every one of theſe parts ſhall be 72 Degrees.

Now to Calculate this Arithmetically; the Chord A B being equal to A L containeth 144°, or twice 72°; the Sine of 72° is 95105, the double whereof is 190210, for the Chord A B or A L, which hath ſuch proportion to the heighth of the Bore A K 200000, as the Diameter of the Ball is to the Bore. I ſay then, the Bore being 200000, and the Diameter of the Ball 190210, the one being ſubtracted from the other, the Difference is 9790, which is the heighth of the Wind: And if you divide the Diameter of the Bore 200000, by the heighth of the Wind 9790, the Quotient will give the Wind to be ſomewhat leſs than the $20\frac{1}{2}$ part of the Bore.

The Diameter of the Bore ——— 200000
The Diameter of the Ball ——— 190210

The Difference is the Wind ——— 9790

9790

9790) 200000 (20⌊42 — The Quotient giveth 20 $\frac{42}{100}$ Times, ſo that it is leſs than 20 $\frac{1}{2}$ Times.
19580
42000
39160
28400
19580
8820

As the Chord of 144°, *viz.* 190210, is in Proportion to the Diameter 200000; So is the half thereof the Sine of 72°, *viz.* 95105, unto the Radius 10000.

The Diameter of a Bore being given, to find the Ball.

Hence it followeth, That as the Radius is in Proportion to the Diameter of the Bore; So is the Sine of 72° 00′ to the Diameter of the Ball.

Or if the Diameter of a Ball were given, to find the Bore.

Then ſhould the Proportion be, as the Sine of 72° 00′, *viz.* 95105 is unto the Diameter of the Ball: So is the Radius 100000 unto the Height of the Bore.

Example 1.

There is a Gun whoſe Bore is 7 Inches Diameter, I would know what Diameter muſt the Ball have, that will fit ſuch a Peece, the Wind duly extracted.

Radius	Inches	Sine of 72° 00′
1⌊00000	7	95105
		7
		6⌊65735

I Anſwer, The Diameter of the Ball that will fit ſuch a Peece, muſt be 6 Inches and $\frac{65}{100}$ parts of an Inch.

Example

Example 2.

There is an Iron Ball whose Diameter is 6 Inches, and weigheth 30 ℔ 6 Ounces, English Weight: I desire to know what heighth the Bore of a Peece will be, which this Ball shall fit, the Wind duly extracted.

Sine of 72° 00′	Inches	Radius
95105	6	100000
		6
		600000

95105)600000(613
570630
293700
285315
8315

I Answer, The Heighth of the Bore of such a Peece of Ordnance will be 6 Inches and $\frac{13}{20}$ parts of an Inch. And so of others.

Observation.

The Diameter of the Peece A C B is $4\frac{1}{7}$ Inches very near, which is the Diameter of a Ball of $9\frac{1}{2}$ ℔ Scots weight.

And the Diameter of the Ball which is A E O 4 Inches, is 8 ℔ Scots weight. Now the aforesaid Diameter A C B of $4\frac{1}{7}$ Inches, is the Diameter of a Ball of $10\frac{1}{8}$ ℔ English weight.

And likewise the Diameter A E O, of 4 Inches, is the Diameter of a Ball of 9 ℔ English weight.

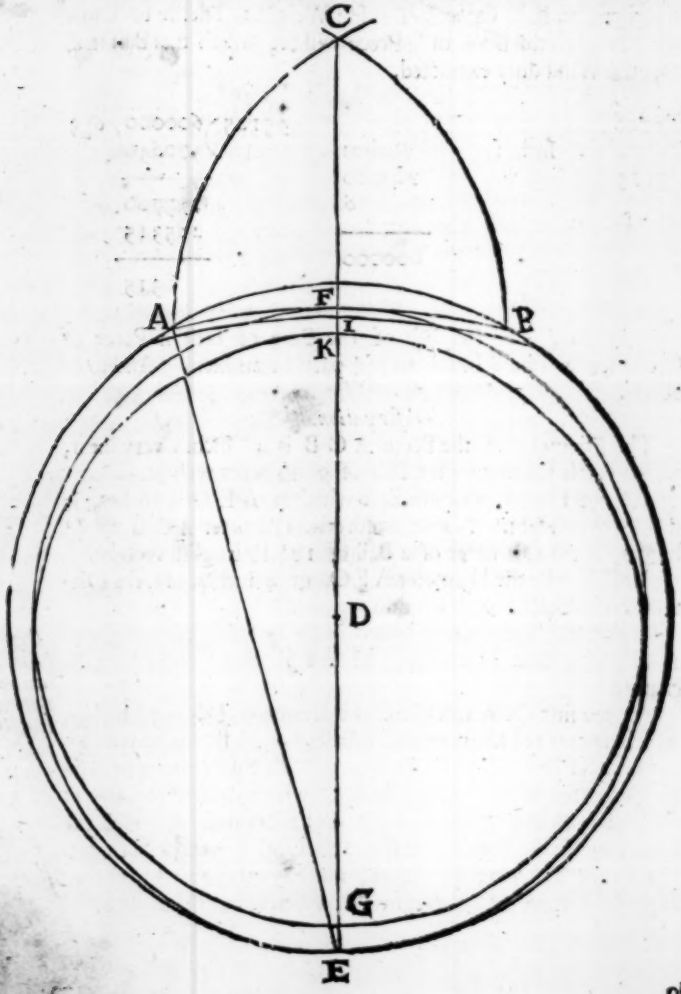
So that the Difference between Scots and English weight is as 8 is to 9; that is to say, That 8 ℔ Scots maketh 9 ℔ English. *There is a Difference between Scots and English Weight, as 8 is to 9.*

For the first Demonstration, the Diameter D B is $3\frac{4}{7}$ Inches, which is near the Diameter of a Ball of $6\frac{17}{20}$ ℔ Scots weight, and near the Diameter of a Ball of $7\frac{1}{16}$ ℔ English weight. And the Diameter D H G is $3\frac{1}{2}$ Inches, which is the Diameter of a Ball of 5 ℔ 6 Ounces very near of Scots weight. And the Diameter of $3\frac{1}{2}$ Inches, is near 6 ℔ English weight, not following the Tables of Mr. *Smith*, nor any other that I have seen as yet set forth; As I intend to Demonstrate in its due place.

Objection.

Objection.

This Geometrical Deſcription may be ſaid by ſome, That they know better; for Mr. *Hexham* hath deciphered the Bore



of

of the Peece, and the Ball in another manner: Therefore I will Demonſtrate the Way that Mr. *Hexam* takes to extract the Wind of a Peece, and thereby to find the true Ball.

Example.

Take the juſt Diameter of the Bore of your Peece, which you divide into two equal parts, and draw the Circle A B E; then the Compaſſes at the ſame ſtation, you place one foot in A, and another in B, and draw the Croſs Arches A C B: From C draw a Line through the Center D to E, and then draw the Line A E: then place one foot of your Compaſſes in E, and draw the Arch A B: then place one foot of your Compaſſes in the Center D, and extend the other to the Arch F, ſo draw the Circle F G: which he ſaith is the way to find a true Ball.

Anſwer to the Objection.

Here you have the Demonſtration of Mr. *Henry Hexham*, where you ſee a groſs miſtake; For as he ſuppoſeth F G, or E K to be the true Ball: And I find I E is the true Ball for that Peece, and have wrought this as you have it in Folio 28. Wherefore I leave the Ingenious Gunner to judg, which of theſe Experiments are the beſt and trueſt.

CHAP. XIV.

The Demonſtration of the Cannon-Bore, and of all other Peeces of Ordnance to the Rabinet, by Letters: As alſo the Geometrical Extracting or Deducing of the Wind or Vent of thoſe Peeces, whereby you may know the exact Diameter of the true Ball fitting thoſe Peeces.

	Weight of Ball. lb	lb
W A is the Bore of the Cannon-Royal; the diſtance betwixt A and B, is the true Vent or Wind, that ought to be betwixt the Ball B, and the Bore A—	64	72
W C is the Bore of the Cannon-Ordinary; the Diſtance C D is the Wind; and D the Height of the Ball	48	54
W E is the Bore of the French-Cannon; E F the Wind; F the Diameter of the Ball	36	40½
W G is the Bore of the Demi-Cannon Royal; G H the Wind; H the Diameter of the Ball —	30	33¾
W I is the Bore of the Demi-Cannon Ordinary; I K the Wind; K the Diameter of the Ball	24	27
W L is the Bore of the Culvering, or Demi-French Cannon; L M the Wind; and M the Diameter of the Bore	18	20¼
W N is the Bore of the Quarter-Cannon Ordinary; N O the Wind; and O the Diameter of the Ball	12	13½
W P is the Bore of the Demi-Culvering; P Q the Wind; and Q the Diameter of the Ball	8	9
W R is the Bore of a large Saker; R S the Wind; and S the Diameter of the Ball	6	6¾

	℔	℔
W T is the Bore of a Saker; V T the Wind; and V the Height of the Ball	5	5 1/8
W X is the Bore of a Minion; X Y the Wind; and Y the Height of the Ball	3	3 1/8
W Z is the Bore of a Faucon; Z X the Wind; and X the Height of the Ball	2	2 1/4
W = is the Bore of a Rabinet; = ⊙ the Wind; and ⊙ the Height of the Ball	1	1 1/8

Note: In the Column next your left hand you have the Scots Weight of the Ball; and in the Column next your right hand you have the Engliſh Weight of the ſame.

The Ancient and Later Rules given for Gunners, to give Powder to great Ordnance of all ſorts, that are drawn on Carriages.

In Ancient times it is ſaid, That the great Chamber'd-Guns, that ſhot Stone-Ball, had for their ordinary one pound of Powder to three pound and half, or at moſt four pound weight of their Ball. This was certainly the firſt Invention of Guns; and in regard they could not caſt Iron, they made their Guns, as Coopers do Cask, with Staves of Iron and Hoops. Likewiſe that thoſe Guns that ſhot Iron-Ball, muſt have to every three pound of Iron-Ball, one pound of Powder; and this they held for a General Rule, not examining the Fortification of their Peeces. Now at this time Powder was made of all the three Ingredients equal, and therefore could not be ſtrong. But afterward it was found, that all ſort of Field-Ordnance, not being Chamber'd, but true Bored, ſhould be loaded in this manner, (to wit) The Gunner ſhall take the Diameter of the Ball, or the Diameter of the Bore of the Peece with a pair of Compaſſes; and this Diameter three times the Gunner muſt ſet off upon his Gun from the Touch-hole toward the Muzzle; which diſtance being fill'd with Powder, then, ſaid they, One pound of Powder was allowed to two pound of Ball: this was the Rule of the Primitive Gunners. But now in our time Powder is ſo variouſly made, and the difference is ſuch, that it is hardly poſſible to the beſt Judgment, to give a true Rule what Powder is ſufficient either for Proof or Action;

According to the cuſtom in former times, the loading of Powder.

and therefore the Gunner ought to try his Powder before he load his Peece; for it is beyond all queſtion, that if the Powder be decayed, there muſt be more of it uſed than of freſh dry Powder: But if Powder be of His Majeſties Tower-Proof, as I am informed, that then the Gunner need not take near ſo much Powder to ſhoot among a party of Men, not being at a great diſtance, as the Peece would crave to batter a Fortification, or Wall, or Gate, or Ship.

But becauſe the young Gunner, that is not yet experimented in his Practice, may be taught how he ſhall load all manner of Guns; and that it is to be underſtood, that ordinarily thoſe that will be called Gunners, though not known in the Art, uſe to load their Guns with half the weight of the Ball of Powder; this they hold for a general Rule to all Guns, which Rule is not to be ſlighted on ſome occaſions, with true-Bored, true-Fortified Ordnance, (yet it may be ſaid, they have this by Tradition) to hold this Rule, without adding to reinforc'd Ordnance, or deducting from thoſe that are leſſened of Metal; ſo that by this, they not having any other Rule, diſcover their own nakedneſs or emptineſs of Art; for I am perſwaded that no experienced Gunner, but will hold that the Gunner ought to ſearch, try, and find the Nature and Fortification of a Gun or Guns, before he do hold himſelf obliged to give a Gun Powder, and thereby to prove a true Charge of Powder for the ſame.

CHAP. XV.

The Reaſons why I give Guns Powder according to their Fortifications.

THeſe firſt Rules were derived from the weight of Ball; but ſince the Rules were made for the weight of the Peece: for they held generally that four ounces of Powder was ſufficient for the Gunner to give a Braſs Gun, to every hundred weight for Service; and three ounces to every hundred weight of Iron Guns. Neither this nor the other being right, for I have ſeen Trumpet-bored Iron Guns of 1200 weight, that could

could not have half the allowed Powder that either of theſe Rules did allow of. And likewiſe I read the Cauſe of the Death of King *James* the Second of *Scotland*, was by the breaking of a great Gun at the Siege of *Roxburgh*.

For theſe and the following Reaſons, I do not hold with that common received Rule, than which many Gunners know no better, but to give Ordnance Powder by the weight of the Gun. For if there be a Peece of Ordnance of Iron weighing 1600 pound weight, likewiſe there is another Peece of the ſame Bore, and of the ſame weight: Now by the Rule of weight it muſt have the like Powder.

Great Cautions to be obſerved in giving Guns Powder.

But will you conſider, for your Inſtruction, this Peece is longer, and having no more Metal in her than the other, of neceſſity ſhe muſt be thinner of Metal; for what ſhe hath of the length, ſhe muſt want of her thickneſs, the Bore being both of one denomination; and ſince ſhe is thinner, it followeth ſhe muſt not have ſo much Powder as the other.

That Guns ought to be proportioned in length to their Fortification.

Likewiſe if by the weight of Guns they ſhould have their Powder, why then do not Founders, where they now make them eight foot long, do not make them ten foot? for it is known to the World, that a Peece of ten foot long will ſhoot further than a Peece of eight foot long, but not without equal Powder: Wherefore it is to be conſidered, they muſt be both of one Fortification; and being alike in ſtrength, the longeſt of the two ought to ſhoot fartheſt, becauſe more of her Powder is ſpent in Fire before ſhe deliver her Ball.

Queſtion.

But ſome may demand what I mean by Fortified Ordnance?

Anſwer.

Curioſity is good, if a man be not taught, he cannot be perfect.

For their Fortification, know that there are Ordnance of ſeveral Fortifications, as is before ſhown in *pag.* 41. where it is ſufficient to be underſtood: and therefore I ſet the Tables of their Powder here, by their proportions and ſhape, and ſhew how to underſtand the Fortifications of Guns, and alſo what Powder ought to be given to Guns according to their Fortifications: As firſt you ſee the Geometrical Demonſtration.

ſtration of *Archimede*'s Proportion in *pag.* 40. how fitly that doth give the true Proportion of all true Bored and true Fortified Iron Ordnance.

Now to be capable of the ſame Proportion Arithmetically, the Proportion is, as 22 the Circumference is unto 7 the Diameter: So muſt 11 the number of times which the Diameter of the Bore meaſured about her Breech be, to a number ſought for; which by the Work I find to be $3\frac{1}{7}$ Diameters of the Bore, which this Peece is of Diameter at the Touch-hole.

22 . 7 11

7

77

22 (77 ($3\frac{11}{11}=\frac{1}{7}$

66

11

Cometh 3 and $\frac{11}{11}$ which is equal to $\frac{1}{7}$.

Rules to find the thickneſs of a True Bored Gun in one ſide Metal, by all the Diameters.

Whilſt the Bore it ſelf is one of the Diameters, that being deduced from $3\frac{1}{7}$, reſts $2\frac{1}{7}$, whereby $1\frac{1}{2}$ is the thickneſs of that Peece in one ſide Metal; and becauſe theſe be the Ordnance of Iron, by which the Ground-Rule may be and ordinarily is laid down, to give Guns their Powder of other Fortifications; for you muſt know that there are ſome leſſened, as thinner Fortified, and ſo cannot have the ſame proportion of Powder, though they ſhoot one and the ſame Ball: Likewiſe there are Reinforc'd, or thicker Ordnance at the charged Cyllinder, which ſhoot the ſame Ball, and muſt have more Powder: So you may ſee that the Iron Peece is 11 Diameters of the Bore about the Breech, 9 Diameters at the Trunions, and 7 at the Neck.

The true Proportion of a true Bored, and true Fortified Peece of Ordnance.

Likewiſe the Braſs Peece is no thicker at the Charged Cylinder, than the Iron Peece is at the Trunnions, yet ſhoots the ſame Ball, and muſt have the ſame Powder; her Proportion is 9 Diameters of the Bore about the Breech, 7 about the Ears, and 5 about the Neck.

Seeing

Seeing you have the Proportion of theſe true Fortified Ordnance; now it followeth of neceſſity that the Powder of all ſuch Ordnance ſhould be known: And as writing at length would be tedious, therefore I have Calculated Tables both for Proof and Action, not denominating the Names or Weight of theſe Ordnance.

But thus fortified with 11 Diameters of the Bore about the Breech, if Iron, Ordnance ſhooting from one pound Ball to 48 pound.

Alſo the ſame Tables will ſerve for Braſs Ordnance, being Fortified with 9 Diameters of the Bore about the Breech, by what name ſoever you define them, ſhooting from one pound Ball, to 48 pound Ball.

The Weight of the Ball and Fortification of Ordnance, are true Rules to give Guns their Powder.

Hereby it is clear, That we are not to examine the Weight of Ordnance, and thereby to give them Powder; but inſpection is to be had to the Fortification of all ſorts of Ordnance, as alſo to their Weight of Ball: To find the Ball fitting a Peece, by extracting the Wind Geometrically, whereby you may have the true Diameter of the Peece, and by the Diameter you may find the Weight of the Ball, as ſhall be ſhown at large in its place, in Tables, Scale, or Height-Rule, and alſo Arithmetically.

But in regard there hath never any pains been taken for regulating the true Powder for Ordnance, I have therefore ſet down theſe Tables following for Powder, for Proof and Action of true Bored and true Fortified Ordnance.

Table

Table for Proof-Powder, for True-Bored and True-Fortified Ordnance, either of Braſs or Iron.

B	P		B	P		B	P	
1	1	00	17	11	12	33	22	00
2	2	00	18	12	00	34	22	10
3	3	00	15	12	11	35	23	05
4	4	00	20	13	06	36	24	00
5	5	00	21	14	00	37	24	10
6	6	00	22	14	11	38	25	05
7	7	00	23	15	05	39	26	00
8	8	00	24	16	00	40	26	10
9	8	12	25	16	11	41	27	05
10	9	08	26	17	05	42	28	00
11	10	00	27	18	00	43	28	10
12	10	08	28	18	11	44	29	05
13	10	14	29	19	05	45	30	00
14	11	02	30	20	00	46	30	10
15	11	05	31	20	10	47	31	05
16	11	08	32	21	05	48	32	00

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, the Powder to prove theſe Guns, which is marked with the Letter P, being true-bored and Fortified, Braſs 9, and Iron 11 Diameters of the Bore about the Breech.

Table for Action, of True-Bored and True-Fortified Ordnance, either of Braſs or Iron.

B	P		B	P		B	P	
1	0	10	17	7	11	33	14	10
2	1	02	18	8	00	34	15	02
3	1	12	19	8	07	35	15	09
4	2	05	20	8	14	36	16	00
5	3	00	21	9	05	37	16	07
6	3	09	22	9	12	38	16	14
7	4	03	23	10	03	39	17	05
8	4	12	24	10	10	40	17	12
9	5	02	25	11	01	41	18	03
10	5	06	26	11	08	42	18	10
11	5	10	27	12	00	43	19	01
12	6	00	28	12	07	44	19	09
13	6	06	29	12	14	45	20	00
14	6	12	30	13	05	46	20	07
15	7	02	31	13	12	47	20	14
16	7	07	32	14	03	48	21	05

In this Table you have the weight of Ball, in the firſt, third, and fifth, Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, being marked with the Letter P, the Powder for Action, for the Guns being Fortified, as before-ſaid, either Braſs or Iron. The Proportion you find in the Copper-Print, N° 1. and N° 2.

A Scale you have for Powder, both for Engliſh and Scots true-Bored true-Fortified Ordnance, Braſs or Iron, for Service, on the Quadrant-Rule.

Having

Having ſhown the Proportion of theſe Ordnance, and their due Powder, both for Proof and Action, it is now neceſſary to know the Proportion of their Ladles, Rammers, and Sponge-heads.

Firſt, Know that all true-Fortified Ordnance have not one Proportion of Powder, as you may ſee by the foregoing Tables; neither muſt their Ladles be of equal length or breadth according to their Bore.

The Proportion of Powder as ſuppoſed.

To make this the more clear, know that the Powder doth not lie in one proportioned length in every true-Bored, true-Fortified Peece; For thoſe that ſhoot from one pound Ball to eight pound, the Powder lieth three Diameters of the Ball in length in a Cartradge, made on a Mould of the Diameter of the Ball.

Names of Guns.

The names of theſe Ordnance are theſe; a Baſe, a Fauconet, a Faucon, a Minion, a Saker, and a Demi-Culvering.

Proportion of Powder, and names of Guns.

Likewiſe for theſe Ordnance that ſhoot from eight pound Ball to eighteen pound, the Powder lieth about two Diameters and a half long in a Cartradge, made on the Diameter of the Ball; their names are Demi-Culvering, Quarter-Cannon, Culvering, or French Demi-Cannon.

Proportion of Powder, and names of Ordnance.

And for theſe true-Bored, true-Fortified Ordnance, that ſhoot from 18 ℔ Ball to 48 ℔, the Powder lieth two Diameters and a quarter long in a Cartradge, made on a Mould of the Diameter of the Ball: The names of theſe Ordnance, are Culvering, or French Demi-Cannon, Demi-Cannon Ordinary, Demi-Cannon Royal, French-Cannon, and Cannon-Ordinary; and other names they have, as Baſilisks, *&c.*

By what is before taught, you may know that the Ladles of Ordnance, though of one Fortification, ought not to be of one Proportion.

Proportion of Ladles.

You muſt make the Ladles for ſmall Ordnance, *viz.* from one pound to eight, of three Diameters of the Ball in length, with as much as will nail it on the Ladle-head, and the breadth of thoſe Ladles ought to be of 1 ⅙, one Diameter and five ſixth parts of the Ball; this Ladle nailed on a wooden head made of purpoſe, three fills thereof of Powder will ſerve for Proof, and two fills of Powder will ſerve for Action to theſe Guns.

And the Ladles for true-Bored, true-Fortified Ordnance, ſhooting from 8 ℔ Ball to 18, ought to be two Diameters

and a half of the Ball long, with as much as will nail it on the Rammer-head; and the Breadth of theſe Ladles, one and five ſixth parts of the Diameter of the Ball: Three of theſe Ladles full of Powder will ſerve for Proof, and two full of Powder will ſerve for Action.

Alſo thoſe Ladles for true-Bored, true-Fortified Ordnance, that ſhoot from 18 ℔ Ball to 48 ℔, or 46 ℔, ought to be two Diameters of the Ball long, and one and five ſixth parts of the Diameter of the Ball broad: Three of theſe Ladles full of Powder will ſerve for Proof, and two full of Powder will ſerve for Action.

CHAP. XVI.

AS there are true-Bored, true-Fortified Ordnance both of Braſs and Iron; that is to ſay, 11 Iron, and 9 Braſs: So there are true-Bored Iron Ordnance of 10 Diameters of the Bore in the Breech, and Braſs of 8 Diameters of the Bore about the Breech.

And becauſe I know that ſome Gunners are not acquainted with Arithmetick, (for I have been at Sea with a Gunner that could not read) and ſo ſuch Men not being able to Calculate the Powder of any Guns: Therefore for the publick good of all, I have taken the pains to calculate Tables for their help; theſe Tables ſerve for Iron of 10 Diameters of the Breech, and may well ſerve for Braſs of 8 of the Breech, as the Figure hereby ſheweth; For the Iron Gun is 10 Diameters of the Bore about the Breech, 8 $\frac{2}{11}$ at the Ears, and 6 $\frac{4}{11}$ at the Neck.

The Braſs Peece is 8 $\frac{2}{11}$ Diameters of the Bore about the Breech, 6 $\frac{4}{11}$ at the Ears, and 4 $\frac{6}{11}$ at the Muzzle: And their Diameters are wrought by the Rule of *Archimedes*; that is to ſay, As 22 is to 7, ſo is 10, 8 $\frac{2}{11}$, 6 $\frac{4}{11}$, or 8 $\frac{2}{11}$, 6 $\frac{4}{11}$, 4 $\frac{6}{11}$, to their Diameters: As you have it clearly demonſtrated in its proper place; For by their Fortifications they are to have their Powder, as the Tables following do ſhew.

This

This Table ſheweth Proof-Powder for Iron Ordnance of 10 Diameters of the Bore, and for Braſs of 8 $\frac{3}{11}$ Diameters of the Bore about the Breech.

B	P	B	P	B	P
1	0 12	17	8 13	33	16 08
2	1 08	18	9 00	34	17 00
3	2 04	19	9 08	35	17 08
4	3 00	20	10 00	36	18 00
5	3 12	21	10 08	37	18 08
6	4 04	22	11 00	38	19 00
7	5 03	23	11 08	39	19 08
8	6 00	24	12 00	40	20 00
9	6 09	25	12 08	41	20 08
10	7 02	26	13 00	42	21 00
11	7 08	27	13 08	43	21 08
12	7 14	28	14 00	44	22 00
13	8 02	29	14 08	45	22 08
14	8 06	30	15 00	46	23 00
15	8 08	31	15 08	47	23 08
16	8 10	32	16 00	48	24 00

This Table ſheweth Powder for Action for Iron Ordnance of 10 Diameters of the Bore about the Breech, and for Braſs of 8 Diameters about the Breech.

B	P	B	P	B	P
1	0 7$\frac{1}{2}$	17	5 12$\frac{1}{2}$	33	11 02
2	0 12	18	6 00	34	11 07
3	1 04	19	6 5$\frac{1}{2}$	35	11 12
4	1 12	20	6 10$\frac{1}{2}$	36	12 01
5	2 04	21	6 15$\frac{1}{2}$	37	12 06
6	2 10$\frac{1}{2}$	22	7 05	38	12 11
7	3 02	23	7 10$\frac{1}{2}$	39	13 02
8	3 07	24	7 15$\frac{1}{2}$	40	13 07
9	3 12	25	8 05	41	13 12
10	4 1$\frac{1}{2}$	26	8 10	42	14 01
11	4 3$\frac{1}{2}$	27	9 00	43	14 06
12	4 8$\frac{1}{2}$	28	9 05	44	14 11
13	4 12$\frac{1}{2}$	29	9 10$\frac{1}{2}$	45	15 00
14	5 1$\frac{1}{2}$	30	10 01	46	15 05
15	5 5$\frac{1}{2}$	31	10 06	47	15 10
16	5 8$\frac{1}{2}$	32	10 10	48	16 00

The Proportion you have in the Copper-Plates, N° 3 and 4.

In the laſt preceding Tables, the firſt Table, or the Table next your left hand, ſheweth the weight of the Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; in the ſecond, fourth, and ſixth Columns, you have the Powder to prove theſe Guns, which are marked with the Letter P; being true Bored and Fortified as before-ſaid.

In the right-hand Table you have the Weight of the Ball, in the firſt, third, and fifth Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, being marked with the Letter P, the Powder for Action for the Guns, being Fortified as before-ſaid, either of Braſs or Iron.

Now there are Ordnance of Iron Fortified with 9 Diameters of the Bore about the Breech, and Braſs of 7 about; And in regard I have ſeen divers miſtakes about giving them Powder, even of Men profeſſing great Knowledg without Reaſon; Therefore I will here deſcribe theſe Tables following, to give them their due Powder. Lower Fortified than 9 of Iron, and 7 of Braſs, you ſhall hardly find a true-Bored Peece of Ordnance; The Iron Ordnance being 9 Diameters of the Bore about the Breech, 7 at the Trunnions, and 5 $\frac{8}{11}$ at the Muzzle or Neck; The Braſs Ordnance of 7 Diameters of the Bore at the Breech, 5 $\frac{8}{11}$ about the Trunnions, and 4 $\frac{1}{11}$ at the Neck.

This Table is the Proof for Iron Ordnance of 9 Diameters in the Breech, and Braſs of 7.

B	P	B	P	B	P
1	0 8½	17	6 06	33	12 00
2	1 1½	18	6 09	34	12 06
3	1 10½	19	6 12	35	12 12
4	2 03	20	7 02	36	13 01
5	2 12	21	7 09	37	13 07
6	3 4½	22	8 00	38	13 13
7	3 13½	23	8 6½	39	14 03
8	4 04	24	8 12	40	14 09
9	4 13	25	9 02	41	14 15
10	5 3½	26	9 6½	42	15 05
11	5 08	27	9 13	43	15 11
12	5 12	28	10 03	44	16 01
13	5 15½	29	10 09	45	16 07
14	6 1½	30	10 15	46	16 13
15	6 2¾	31	11 05	47	17 03
16	6 04	32	11 10½	48	17 08

This Table is the Powder for Action, for Iron of 9, & Braſs of 7 Diameters of the Bore about the Breech.

B	P	B	P	B	P
1	0 5½	17	4 3½	33	8 00
2	0 10	18	4 06	34	8 4½
3	0 15	19	4 9½	35	8 8½
4	1 04	20	4 13	36	8 13
5	1 10	21	5 00	37	9 01
6	1 15½	22	5 05	38	9 04
7	2 05	23	5 09	39	9 08
8	2 09	24	5 13	40	9 11
9	2 12	25	6 0¼	41	9 14
10	2 15½	26	6 4¾	42	10 00
11	3 1½	27	6 09	43	10 03
12	3 4½	28	6 13	44	10 5½
13	3 7¼	29	7 0¾	45	10 08
14	3 11	30	7 4½	46	10 12½
15	3 14¾	31	7 09	47	11 co
16	4 01	32	7 13½	48	11 03

The Proportions you have in the Copper Plate, N° 5 and 6.

Now

Now as these are the Tables for true-Fortified, and lessened in Metal, I hold convenient to give Tables for Reinforc'd Ordnance; these have commonly, being Brass, 10 Diameters of the Bore about the Breech, and Iron 12 about the Breech. And though to some these Tables may seem foolish, I have seen those who have been esteemed Able Gunners, that knew not how to give such Guns Powder; yea, they have in my presence wagered, and not one of them knew what they wagered concerning two such Guns lying at the Head of *Terveer* confer; where amongst six Gunners, one only understood to give these two Guns their true Powder; as at the Discussion, a Gentleman of the Ordnance to the States did manifest in favour of the one Man.

How many Gunners at the Wager, and but one capable.

I also have been in contest with one professing great Art, and was a rare Person in Art: Yet in the Castle of *Edinburgh*, there was a Gally-Gun of Brass that did shoot 28 ℔ Ball; and thereby he did conclude that Peece to have 13 or 14 ℔ of Powder for Action: In hearing this Expression I did laugh: The Gentleman was offended, and asked if I could teach him? (it was but in disdain): I answered, Sir, if you know not better than you express, I am sure I am able to teach you in this Point: Whereupon he went out at the Castle-Gate, and was ever mine Enemy from that time forth. And to satisfy the Reader, I will give the Dimensions of that Peece: She was but 7 Diameters of the Bore about the Breech, and 5 ½ about the Muzzle, for she was plain without Rings, except the Base and Muzzle-Rings, or Cornish-Rings; so that by her Fortication she could suffer but 6 ℔ and 13 ounces of Powder; and with so much I have caused her to be discharged divers times, and could do Service with this Peece, which could not be done with a true-Fortified Peece; for with this Peece I have shot over the Steeple of *Edinburgh*, and the Ball hath fallen at the next Lodging where *Cromwel* did lie. And this I did for three times together. Therefore I say, An able Man may be mistaken of a Gun, when he neither knoweth the Fortification nor Proportion how to work to give a Peece Powder.

This Dispute was between a General Person and a Gunner.

What may be done with a lessened Piece, as if it were a Master-Piece.

So to avoid trouble to Artists for Calculating, and to instruct those Gunners that are not capable of Calculation, I have here

to;

ſet down the Demonſtration of theſe Guns of Iron, having 12 about the Breech, and Braſs having near 10 Diameters about the Breech, and are called Reinforc'd Ordnance. The Figures following Demonſtrate the true Proportion of theſe Reinforc'd Ordnance which require more Powder than true-Bored, true-Fortified Ordnance, as you may ſee by the Tables following; which Tables might have been firſt of all: But I obſerve that the Ground-Rule muſt be put in the firſt place; And thoſe that do take their Dimenſions from it do follow, whether they be Reinforc'd or leſſened of Metal, ſuch as are formerly deſcribed.

Theſe following Tables, are Tables for Reinforc'd Ordnance, which are ſuch as have more ſtrength of Fortification, and are more able to endure firing: Such as the Bazilisk, Serpents, or Slings, *&c.* and are good to ſhoot with at a great diſtance. Having, as I ſuppoſe, given a full account of the true allowance of Powder for all ſorts of true-Bored Ordnance, both for Proof and Action, whether they be Braſs or Iron Guns, it followeth that the Gunner ought to know how to go to work with his Peece, when he is to apply theſe Tables, by which he is to give fire.

Theſe Rules are to be obſerved.

Firſt, he ſhall take a piece of Twine, which is to be well waxed, as the Shoemakers do their Thread, that it do not ſtretch nor ſhrink; then meaſure the Peece about at the Touch-hole betwixt the Rings, and taking with a pair of Compaſſes the Diameter of the Bore at the Muzzle, meaſure the Twine how many Diameters of the Bore is contained about the Breech of the Peece, that keep in memory. Now you are to know what Ball fits that Peece, as is plainly ſet down in *pag.* 42. Geometrically; but may be exactly found in the Tables of Height and Weight of Shot, and in the Tables of Diameters of Bores, either Scots or Engliſh. When you have found the Diameter of the Ball, if you cannot Arithmetically find the Weight by the Diameter of the Ball, then you may reſort to the Tables for ſuch Fortifications, and next the weight of Ball you have the weight of Powder for that Peece: but you muſt be ſure your Peece muſt be true-bored, as is mentioned in *pag.* 58. For if the Peece be either Taper'd, Chamber'd, or Trumpet-bored, theſe Tables will do no ſervice.

Proof-

Proof-Powder for Reinforced Ordnance, or Iron Guns of 12 Diameters of the Bore about the Breech, and Braſs Guns near 10 Diameters.

B	P	B	P	B	P
1	1 05	17	15 01	33	28 08
2	2 09	18	15 05	34	29 10
3	3 10	19	16 07	35	30 08
4	5 01	20	17 05	36	31 08
5	6 08	21	18 02	37	32 04
6	8 05	22	18 15	38	33 01
7	9 01	23	20 00	39	34 02
8	10 06	24	20 12	40	35 00
9	11 06	25	21 09	41	35 12
10	12 05	26	22 08	42	36 08
11	12 15	27	23 07	43	37 08
12	13 10	28	24 12	44	38 05
13	14 01	29	25 01	45	39 04
14	14 07	30	26 00	46	40 02
15	14 10	31	26 14	47	41 00
16	14 14	32	27 10	48	41 12

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Powder to prove theſe Guns, which is marked with the Letter P; being true-bored and Fortified, as above written.

Powder for Action of Reinforc'd Ordnance, or Iron Guns of 12 Diameters of the Bore about the Breech; and Braſs near 10 Diameters about the Breech.

B	P	B	P	B	P
1	0 13	17	10 02	33	19 04
2	1 7½	18	10 05	34	19 14
3	2 4½	19	11 01	35	20 08
4	3 00	20	11 10	36	21 01
5	3 15	21	12 03	37	21 09
6	4 14	22	12 15	38	22 01
7	5 08	23	13 08	39	22 10
8	6. 02	24	14 00	40	23 03
9	6 10	25	14 08	41	23 12
10	7 02	26	15 00	42	24 06
11	7 09	27	15 12	43	24 14
12	7 15	28	16 03	44	25 08
13	8 05	29	16 12	45	26 03
14	8 14	30	17 04	46	26 13
15	9 06	31	18 01	47	27 04
16	9 12	32	18 10	48	28 14

In this Table you have the weight of Ball, in the firſt, third, and fifth, Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Powder for Action, which is marked with the Letter P; being true-bored and Fortified, as above written.

Theſe Proportions you have in the Copper Plate, N° 7 and 8.

CHAP.

CHAP. XVII.

To find the Weight of an Iron Ball in Engliſh Inches Arithmetically for Scots Weight.

FOr thoſe that cannot find the Weight of the Ball by Aritbmetick, I will here ſhew them a Rule, and alſo Tables which I have Calculated, as well Decimally, as in Pounds, Ounces, and Drams, from eight parts, to eight of an Inch of the Diameter of a Ball, unto 10 Inches Diameter, both in Scots and Engliſh Weight, and alſo in Scots and Engliſh Inches, for the Artificial Gunner his more eaſe.

It falls out many times that the Gunner cannot find Weights and Scales to weigh his Shot; it is therefore neceſſary the Gunner ſhould know how to find the Weight of his Shot Arithmetically; as thus, If you deſire to know the Weight of a Ball, whoſe Diameter is juſt Inches, without any Fraction or parts of an Inch, then you are to multiply the Diameter Cubically; then double that Product, and divide the Total by 16, you have in the Quotient the Pounds that the Ball weigheth; and what Remainer you have over, you ſhall know that Remainer is Ounces.

Example.

There is a Ball of 4 Inches Diameter given, to find his Weight: The Cube of 4 is 64, which being doubled maketh 128; this 128 being divided by 16, (the ounces in a pound) the Quotient giveth 8, which is 8 ℔ of Scots Weight which that Ball doth weigh.

Behold

Behold the Work.

4
4
16
4
64
64
128

16)128(8 lb
128
...

Eight pound of Scots weight is the true weight of that Ball.

And becauſe every Gunner hath not Arithmetick at his Fingers ends, and alſo to eaſe the Artificial Gunner, I have taken the pains to Calculate theſe following Tables, both of Scots and Engliſh Weight and Meaſure, *&c.* as before-ſaid. I do not take them on truſt as others do, but have Calculated them my ſelf from the Ground-Rules, and have given credit to none, becauſe I never found any yet truly ſet forth.

Tables for Iron Ball, whose Diameters being measured with English Inches, are exactly Calculated for Scots Weight, from eight parts to eight parts of English Inches, unto ten Inches: Decimally.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
1/8	00	00024	2 1/8	02	26099	5 1/8	16	82642	7 1/8	55	41528
1/4	00	00195	2 1/4	02	59961	5 1/4	18	08789	7 1/4	58	18555
3/8	00	00659	2 3/8	02	97046	5 3/8	19	41089	7 3/8	61	04663
1/2	00	01562	3	03	37500	5 1/2	20	79687	8	64	00000
5/8	00	03052	3 1/8	03	81470	5 5/8	22	24731	8 1/8	67	04712
3/4	00	05273	3 1/4	04	29102	5 3/4	23	76367	8 1/4	70	18945
7/8	00	08374	3 3/8	04	80542	5 7/8	25	34741	8 1/2	73	42847
1	00	12500	3 1/2	05	35937	6	27	00000	8 1/2	76	76562
1 1/8	00	17798	3 5/8	05	95435	6 1/8	28	72290	8 5/8	80	20240
1 1/4	00	24414	3 3/4	06	59180	6 1/4	30	51758	8 3/4	83	74023
1 3/8	00	32495	3 7/8	07	27319	6 3/8	32	38550	8 7/8	87	38062
1 1/2	00	42187	4	08	00000	6 1/2	34	32812	9	91	12500
1 5/8	00	53638	4 1/8	08	77368	6 5/8	36	34692	9 1/8	94	97485
1 3/4	00	66992	4 1/4	09	59570	6 3/4	38	44336	9 1/4	98	93164
1 7/8	00	82397	4 3/8	10	46753	6 7/8	40	61890	9 3/8	102	99683
2	01	00000	4 1/2	11	39062	7	42	87500	9 1/2	107	17187
2 1/8	01	19946	4 5/8	12	36645	7 1/8	45	21313	9 5/8	111	45825
2 1/4	01	42383	4 3/4	13	39648	7 1/4	47	63476	9 3/4	115	85742
2 3/8	01	67456	4 7/8	14	48218	7 3/8	50	14136	9 7/8	120	37085
2 1/2	01	95312	5	15	62500	7 1/2	52	73437	10	125	00000

In this Table you have eight Columns; in the first, third, fifth, and seventh Columns, there are the Inches, and eight parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B: And in the second, fourth, sixth, and eighth Columns, you have the weight of these Diameters of Iron Ball in Scots Weight; under Li. you have Pounds; and under Parts, you have the Decimal parts of Pounds.

Tables

Tables for Iron Ball, whose Diameters being measured with English Inches, are exactly Calculated for Scots Weight, in Pounds, Ounces and Drams, from eight parts to eight parts of English Inches, unto 10 Inches.

B	Li.	On.	Dr.	B	Li.	On.	Dr.	B	Li.	On.	Dr.
1	00	02	00	4	08	00	00	7	42	14	00
1⅛	00	02	14	4⅛	08	12	06	7⅛	45	03	07
1¼	00	03	14	4¼	09	09	08	7¼	47	10	01
1⅜	00	05	03	4⅜	10	07	08	7⅜	50	02	04
1½	00	06	12	4½	11	06	04	7½	52	11	12
1⅝	00	08	09	4⅝	12	05	04	7⅝	55	06	10
1¾	00	10	11	4¾	13	06	05	7¾	58	02	15
1⅞	00	13	03	4⅞	14	07	11	7⅞	61	00	12
2	01	00	00	5	15	10	00	8	64	00	00
2⅛	01	03	03	5⅛	16	13	04	8⅛	67	00	12
2¼	01	06	12	5¼	18	01	06	8¼	70	03	00
2⅜	01	10	13	5⅜	19	06	09	8⅜	73	06	14
2½	01	15	04	5½	20	12	12	8½	76	12	04
2⅝	02	04	03	5⅝	22	03	15	8⅝	80	03	04
2¾	02	09	09	5¾	23	12	03	8¾	83	11	13
2⅞	02	15	08	5⅞	25	05	09	8⅞	87	06	01
3	03	06	00	6	27	00	00	9	91	02	00
3⅛	03	13	00	6⅛	28	11	09	9⅛	94	15	10
3¼	04	04	10	6¼	30	08	04	9¼	98	14	14
3⅜	04	12	14	6⅜	32	06	03	9⅜	102	15	15
3½	05	05	12	6½	34	05	04	9½	107	02	11
3⅝	05	15	04	6⅝	36	05	09	9⅝	111	07	05
3¾	06	09	07	6¾	38	07	01	9¾	115	13	11
3⅞	07	04	06	6⅞	40	09	14	9⅞	120	05	15

In this Table you have six Columns; in the first, third, and fifth Columns, there are the Inches, and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the second, fourth, and sixth Columns, you have the Weight of these Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, under On. Ounces, and under Dr. Drams.

The Height-Rule you have on the side of the Quadrant, which proves this Table.

This will be Admirable to some Gunners, and especially English, because their Weight and the Scots Weight doth not hold alike; I have perused the Tables of Weight by most of the Authors of Gunnery, and I find them all to agree, and hold firm, as Mr. *Nye* writeth. But indeed I find nothing of ingenuity, for a Man to copy a Table from anothers Works, and never examine the Truth of the Work; But I have made use of their own Ground-Rule, and find not one of them to have wrought it, or set the Table down truly.

I will here set down the Ground-Rule by which they are to make their Table, that the Ingenious Gunner may Correct it himself at his pleasure.

Mr. Nye *says, That two Inches Diameter, is 1 pound 1 ounce.*

Thus they set it down, 2 Inches Diameter give 1 pound 1 ounce.

Now having this for a Rule, you may, if you please, make a Table.

Behold the Work.

	℔	Inches.			
If 2	gives $1\frac{1}{16}$,	What $2\frac{1}{4}$		On.	Dr.
8	17	9	512)12393(24	3	
8		9	1024		
64		81	2153		
8		9	2048		
512		729	105		
		17	16		
		5103	630	512)1680(3	
		729	105	1536	
		12393	1680	144	

Where you see, if 2 Inches give one pound one ounce, $2\frac{1}{4}$ Inches giveth 1 pound, 8 ounces, and 3 drams, whereof 16 make an ounce. And by their Tables, because they would be

be near the Right, they set down 4 Inches to give 8 pound 15 ounces; where by this Work it will be but 8 pound 8 ounces.

But there is another more sure way, by this Work following: Say, As 2 Inches is to one pound two ounces: So is the Diameter given, unto the Weight required. *The truest Rule.*

Behold the Work.

Inches.	lb.	Inches.
2	1 1/2	3
2		3
4	18	9
2		3
8		27
		18
		216
		27
		486

For by this Rule I have Calculated the Table following.

8)486(60
48
6

12 | 3
3 | 4
16

16)60(3 lb 12 ounces, 12 drams.
48 or 1/4 of an ounce.
12

Tables

Tables for Iron Ball, whose Diameters being measured with English Inches, are exactly Calculated Decimally for English Weight; from eight parts to eight parts of English Inches, unto 10 *Inches.*

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
1/8	00	00027	2 1/8	02	54361	5 1/8	18	92972	7 1/8	62	34219
1/4	00	00220	2 1/4	02	92456	5 1/4	20	34888	7 1/4	65	45874
3/8	00	00742	2 3/8	03	34177	5 3/8	21	83725	7 3/8	68	67746
1/2	00	01758	3	03	79687	5 1/2	23	39648	8	72	00000
5/8	00	03433	3 1/8	04	39153	5 5/8	25	02823	8 1/8	75	42801
3/4	00	05933	3 1/4	04	82739	5 3/4	26	73413	8 1/4	78	96313
7/8	00	09421	3 3/8	05	40610	5 7/8	28	51584	8 3/8	82	60703
1	00	14062	3 1/2	06	02930	6	30	37500	8 1/2	86	36133
1 1/8	00	20023	3 5/8	06	69864	6 1/8	32	31336	8 5/8	90	22769
1 1/4	00	27466	3 3/4	07	41577	6 1/4	34	33228	8 3/4	94	20776
1 3/8	00	36557	3 7/8	08	18234	6 3/8	36	43369	8 7/8	98	30319
1 1/2	00	47461	4	09	00000	6 1/2	38	61914	9	102	51562
1 5/8	00	60342	4 1/8	09	87039	6 5/8	40	89029	9 1/8	106	84671
1 3/4	00	75366	4 1/2	10	79517	6 3/4	43	24878	9 1/4	111	29810
1 7/8	00	92697	4 3/8	11	77597	6 7/8	45	69626	9 3/8	115	87143
2	01	12500	4 1/2	12	81445	7	48	23437	9 1/2	120	56836
2 1/8	01	34940	4 5/8	13	91226	7 1/8	50	86478	9 5/8	125	39053
2 1/4	01	60181	4 3/4	15	07104	7 1/4	53	58911	9 3/4	130	33960
2 3/8	01	88388	4 7/8	16	29245	7 3/8	56	40903	9 7/8	135	41721
2 1/2	02	19727	5	17	57812	7 1/2	59	32617	10	140	62500

In this Table you have eight Columns, in the first, third, fifth, and seventh Columns, are the Inches and eight parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the second, fourth, sixth, and eighth Columns, you have the Weight of these Diameters of Iron Ball in English Weight: under Li. you have Pounds, and under Parts, you have the Decimal Parts of Pounds.

Tables

Tables for Iron Ball, whose Diameters being measured with English Inches, are exactly Calculated for English Weight, in Pounds, Ounces and Drams, from eight parts to eight parts of English Inches, unto 10 Inches.

B	Li.	On.	Dr.
1	00	02	04
1⅛	00	03	03
1¼	00	04	06
1⅜	00	05	14
1½	00	07	10
1⅝	00	09	10
1¾	00	12	01
1⅞	00	14	13
2	01	02	00
2⅛	01	05	09
2¼	01	09	10
2⅜	01	14	02
2½	02	03	03
2⅝	02	08	11
2¾	02	14	13
2⅞	03	05	07
3	03	12	12
3⅛	04	04	11
3¼	04	13	04
3⅜	05	06	08
3½	06	00	08
3⅝	06	11	03
3¾	07	06	10
3⅞	08	02	15

B	Li.	On.	Dr.
4	09	00	00
4⅛	09	13	15
4¼	10	12	12
4⅜	11	12	07
4½	12	13	00
4⅝	13	14	10
4¾	15	01	02
4⅞	16	04	11
5	17	09	04
5⅛	18	14	14
5¼	20	05	09
5⅜	21	13	06
5½	23	06	05
5⅝	25	00	07
5¾	26	11	12
5⅞	28	08	04
6	30	06	00
6⅛	32	05	00
6¼	34	05	05
6⅜	36	06	15
6½	38	09	14
6⅝	40	14	04
6¾	43	04	00
6⅞	45	11	02

B	Li.	On.	Dr.
7	48	03	12
7⅛	50	13	13
7¼	53	09	07
7⅜	56	06	09
7½	59	05	03
7⅝	62	05	08
7¾	65	07	05
7⅞	68	10	13
8	72	00	00
8⅛	75	06	14
8¼	78	15	07
8⅜	82	09	11
8½	86	05	13
8⅝	90	03	10
8¾	94	03	05
8⅞	98	04	14
9	102	08	04
9⅛	106	13	09
9¼	111	04	12
9⅜	115	13	15
9½	120	09	02
9⅝	125	05	04
9¾	130	05	07
9⅞	135	06	11

In this Table you have six Columns, in the first, third, and fifth Columns, there are the Inches and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the second, fourth, and sixth Columns, you have the Weight of these Diameters of Iron Ball in English weight; under Li. you have Pounds, under On. Ounces, and under Dr. you have Drams.

This Height-Rule you have on the side of the Quadrant. By

By which Work and Tables you may examine any other Weight, if you will compare.

Example.

As in the preceding Example, 3 Inches Diameter giveth 3 pound 12 ounces and 12 drams, as you may ſee by the Work.

Alſo I demand what giveth 4 Inches of Diameter.

Inches.	lb	Inches.
2	$1\frac{2}{16}$	4
2	18	4
4		16
2		4
8		64
		18
		512
		64
		1152

~~88~~
~~1152~~ (~~144~~ (9 pound.
~~888~~ (~~16~~ (

Anſwer, it giveth 9 lb.

Another Example.

If 4 Inches of Diameter give 9 pound weight, what ſhall 8 Inches give? Anſwer, 72 pound.

Inches.	lb	Inches.
4	9	8
4		8
16		64
4		8
64		512
		9
		4608

64) 4608 (72 lb
448 ·
128
128
...

Another

Another Example with a Fraction.

If 4 Inches of Diameter give 9 pound, what ſhall 6 ¼ Inches give?

Inches.	lb	Inches.
4	9	6¼
4		
27		
16		27
16		
189		
96		54
16		
729		
256		27
5103		
1458		
19683		
9		
177147		

256)177147(691
1536
2354
2304
507
256
251

16)691(43 lb
64
51
48
3 Ounces.

I Anſwer, This Ball of 6 ¼ Inches Diameter, weigheth 43 pound 4 ounces *ferè*; which proves both the Work and Tables to be true and juſt.

Obſervation.

It is to be obſerved, That as there is a difference betwixt Scots and Engliſh Weight, *viz.* as 8 to 9, which was mentioned in *pag.* 54. ſo is there likewiſe a difference between Scots and Engliſh Inches, which is as 9 to 10; that is to ſay, 9 Engliſh Inches make 10 Scots Inches; as it appeareth in the Tables following. *The difference betwixt Scots and Engliſh Weight.*

Tables for Iron Ball, whose Diameters being measured with Scots Inches, are exactly Calculated Decimally for Scots Weight; from eight parts to eight parts of Scots Inches, unto 10 Inches.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
1/8	00	00018	2 5/8	01	64826	5 1/8	12	26646	7 1/8	40	39774
1/4	00	00142	2 3/4	01	89512	5 1/4	13	18607	7 1/4	42	41726
3/8	00	00481	2 7/8	02	16546	5 3/8	14	15054	7 7/8	44	50299
1/2	00	01139	3	02	46037	5 1/2	15	16092	8	46	65900
5/8	00	02225	3 1/8	02	78091	5 5/8	16	21829	8 1/8	48	48877
3/4	00	03844	3 1/4	03	12815	5 3/4	17	32372	8 1/4	51	16811
7/8	00	06105	3 3/8	03	50315	5 7/8	18	47826	8 3/8	53	52935
1	00	09112	3 1/2	03	90698	6	19	68300	8 1/2	55	96214
1 1/8	00	12975	3 5/8	04	34072	6 1/8	20	93899	8 5/8	58	46754
1 1/4	00	17798	3 3/4	04	80542	6 1/4	22	24731	8 3/4	61	04663
1 3/8	00	23689	3 7/8	05	30216	6 3/8	23	60903	8 7/8	63	70047
1 1/2	00	30755	4	05	83200	6 1/2	25	02520	9	66	43012
1 5/8	00	39102	4 1/8	06	39601	6 5/8	26	49691	9 1/8	69	23667
1 3/4	00	48837	4 1/4	06	99527	6 3/4	28	02521	9 1/4	72	12117
1 7/8	00	60068	4 3/8	07	63083	6 7/8	29	61118	9 3/8	75	08469
2	00	72900	4 1/2	08	30377	7	31	25587	9 1/2	78	12830
2 1/8	00	87441	4 5/8	09	01515	7 1/8	32	96038	9 5/8	81	25307
2 1/4	01	03797	4 3/4	09	76604	7 1/4	34	72574	9 3/4	84	46006
2 3/8	01	22075	4 7/8	10	55751	7 3/8	36	55305	9 7/8	87	75035
2 1/2	01	42383	5	11	39062	7 1/2	38	44336	10	91	12500

In this Table you have eight Columns, in the first, third, fifth, and seventh Columns, are the Inches and eight parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the second, fourth, sixth, and eighth Columns, you have the Weight of these Diameters of Iron Ball in Scots Weight: under Li. you have Pounds, and under Parts, you have the Decimal Parts of Pounds.

Tables

Tables for Iron Ball, whose Diameters being measured with Scots Inches, are exactly Calculated for Scots Weight, in Pounds, Ounces and Drams, from eight parts to eight parts of Scots Inches, unto 10 Inches.

B	Li.	On.	Dr.	B	Li.	On.	Dr.	B	Li.	On.	Dr.
1	00	01	07	4	05	13	05	7	31	04	02
1⅛	00	02	01	4⅛	06	06	05	7⅛	32	15	06
1¼	00	02	14	4¼	06	15	06	7¼	34	11	10
1⅜	00	03	13	4⅜	07	10	01	7⅜	36	08	14
1½	00	04	15	4½	08	04	14	7½	38	07	02
1⅝	00	06	04	4⅝	09	00	04	7⅝	40	06	06
1¾	00	07	13	4¾	09	12	04	7¾	42	06	11
1⅞	00	09	10	4⅞	10	08	15	7⅞	44	08	01
2	00	11	11	5	11	06	04	8	46	10	08
2⅛	00	14	00	5⅛	12	04	05	8⅛	48	07	13
2¼	01	00	10	5¼	13	02	15	8¼	51	02	11
2⅜	01	03	09	5⅜	14	02	07	8⅜	53	08	08
2½	01	06	13	5½	15	02	09	8½	55	15	06
2⅝	01	10	06	5⅝	16	03	08	8⅝	58	07	08
2¾	01	14	05	5¾	17	05	03	8¾	61	00	12
2⅞	02	02	10	5⅞	18	07	10	8⅞	63	11	03
3	02	07	06	6	19	10	15	9	66	06	14
3⅛	02	12	08	6⅛	20	15	00	9⅛	69	03	13
3¼	03	02	01	6¼	22	03	15	9¼	72	01	15
3⅜	03	08	01	6⅜	23	09	12	9⅜	75	01	06
3½	03	14	08	6½	25	00	06	9½	78	02	01
3⅝	04	05	07	6⅝	26	07	15	9⅝	81	04	01
3¾	04	12	14	6¾	28	00	06	9¾	84	07	06
3⅞	05	04	13	6⅞	29	09	12	9⅞	87	12	00

In this Table you have six Columns; in the first, third, and fifth Columns, there are the Inches, and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the second, fourth, and sixth Columns, you have the Weight of these Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, under On. Ounces, and under Dr. Drams.

Tables for Iron Ball, whose Diameters being measured with Scots Inches, are exactly Calculated for English Weight, from eight parts to eight parts of Scots Inches, unto ten Inches, Decimally.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
1/8	00	00020	2 1/8	01	85429	5 1/8	13	79976	7 1/8	45	44746
1/4	00	00160	2 1/4	02	13 00	5 1/4	14	83433	7 1/4	47	71942
3/8	00	00541	2 7/8	02	43615	5 3/8	15	91936	7 7/8	50	06587
1/2	00	01281	3	02	76792	5 1/2	17	05604	8	52	48800
1/8	00	02503	3 1/8	03	12853	5 5/8	18	24558	8 1/8	54	98702
3/4	00	04325	3 1/4	03	51947	5 3/4	19	48918	8 1/4	57	56413
7/8	00	06868	3 3/4	03	94105	5 7/8	20	78805	8 1/4	60	22052
1	00	10252	3 1/2	04	39536	6	22	14337	8 1/2	62	95741
1 1/8	00	14596	3 5/8	04	88331	6 1/8	23	55637	8 5/8	65	77600
1 1/4	00	20023	3 3/4	05	40610	6 1/4	25	02823	8 3/4	68	67746
1 3/8	00	26650	3 7/8	05	96493	6 3/8	26	56016	8 7/8	71	66303
1 1/2	00	34599	4	06	56100	6 1/2	28	15335	9	74	73389
1 5/8	00	43990	4 1/8	07	19552	6 5/8	29	80902	9 1/8	77	89125
1 3/4	00	54942	4 1/4	07	86968	6 3/4	31	52836	9 1/4	81	13631
1 7/8	00	67576	4 3/8	08	58468	6 7/8	33	31257	9 3/8	84	47027
2	00	82012	4 1/2	09	34174	7	35	16286	9 1/2	87	89433
2 1/8	00	98371	4 5/8	10	14204	7 1/8	37	08042	9 5/8	91	40970
2 1/4	01	16772	4 3/4	10	98680	7 1/4	39	06646	9 3/4	95	01757
2 3/8	01	37335	4 7/8	11	87720	7 3/8	41	12218	9 7/8	98	71914
2 1/2	01	60181	5	12	81445	7 1/2	43	24878	10	102	51562

In this Table you have eight Columns; in the first, third, fifth, and seventh Columns, there are the Inches, and eight parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B: And in the second, fourth, sixth, and eighth Columns, you have the weight of these Diameters of Iron Ball in English Weight; under Li. you have Pounds; and under Parts, you have the Decimal parts of Pounds.

Tables

Tables for Iron Ball, whose Diameters being measured with Scots Inches, are exactly Calculated for English Weight, in Pounds, Ounces, and Drams from eight parts to eight parts of Scots Inches, unto 10 Inches.

B	Li.	On.	Dr.
1	00	01	10
1⅛	00	02	05
1¼	00	03	03
1⅜	00	04	04
1½	00	05	09
1⅝	00	07	01
1¾	00	08	13
1⅞	00	10	13
2	00	13	02
2⅛	00	5	12
2¼	01	02	11
2⅜	01	06	00
2½	01	09	10
2⅝	01	13	11
2¾	02	02	02
2⅞	02	07	00
3	02	12	05
3⅛	03	02	01
3¼	03	08	05
3⅜	03	15	01
3½	04	06	05
3⅝	04	14	02
3¾	05	06	08
3⅞	05	15	07
4	06	09	00
4⅛	07	03	02
4¼	07	13	15
4⅜	08	09	06
4½	09	05	07
4⅝	10	02	04
4¾	10	15	13
4⅞	11	14	01
5	12	13	00
5⅛	13	12	13
5¼	14	13	06
5⅜	15	14	11
5½	17	00	14
5⅝	18	03	15
5¾	19	07	13
5⅞	20	12	10
6	22	02	05
6⅛	23	08	14
6¼	25	00	07
6⅜	26	08	15
6½	28	02	07
6⅝	29	12	15
6¾	31	08	07
6⅞	33	05	00
7	35	02	10
7⅛	37	01	05
7¼	39	01	01
7⅜	41	01	15
7½	43	04	0⁰
7⅝	45	07	03
7¾	47	11	08
7⅞	50	10	01
8	52	07	13
8⅛	54	15	13
8¼	57	09	00
8⅜	60	03	08
8½	62	15	05
8⅝	65	12	07
8¾	68	10	13
8⅞	71	10	10
9	74	11	12
9⅛	77	14	04
9¼	81	02	03
9⅜	84	07	08
9½	87	14	05
9⅝	91	06	09
9¾	95	00	04
9⅞	98	11	08

In this Table you have six Columns, in the first, third, and fifth Columns, there are the Inches and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B: and in the second, fourth, and sixth Columns, you have the Weight of these Diameters of Iron Ball in English weight; under Li. you have Pounds, under On. Ounces, and under Dr. you have Drams.

CHAP.

CHAP. XVII.

The Uſe of the preceding Tables.

Uſe of the Tables of Iron Ball, meaſured with Scots Inches.

IF the Diameter of an Iron Ball be meaſured with Scots Inches, I would know what the ſame Ball weigheth in Engliſh Weight.

Example.

There is an Iron Ball, whoſe Diameter is 5 ½ Scots Inches; I demand what the ſame Ball weighs in Engliſh Weight.

Look in the Table in *pag.* 80. under B in the fifth Column, where you find 5 ½ Inches; and right againſt it, in the ſixth Column, you have 17 pound and $\frac{5}{10}\frac{5}{00}$ pounds, which is the juſt weight of the ſame Ball.

Or otherwiſe, Look in the Table in *pag.* 81. under B, in the third Column, where you find 5 ½ Inches; and right againſt it, in the fourth Column, you have 17 pound, 00 ounces, and and 14 drams, which is alſo the juſt Weight of the ſame Ball.

Or if the Diameter of an Iron Ball be meaſured with Scots Inches; I deſire to know what the ſame Ball weigheth in Scots Weight.

Example.

There is an Iron Ball whoſe Diameter is 6 ⅛ Scots Inches; I demand what doth the ſame Ball weigh in Scots Weight.

Look in the Table in *pag.* 78. under B, in the fifth Column, where you find 6 ⅛ Inches; and right againſt it, in the ſixth Column, you have 20 pound and $\frac{9}{10}\frac{3}{00}$ parts of a pound, which is the juſt weight of the ſame Ball in Scots Weight.

Or otherwiſe, Look in the Table in *pag.* 79. under B, in the third Column, where you find 6 ⅛ Inches; and right againſt it, in the fourth Column, you have 20 pounds and

15

15 ounces, which is alſo the juſt weight of the ſame Ball in Scots Weight. And this I will aſſure you to be truth, becauſe I have calculated all theſe Tables with my own Hand, and they are ſince reviſed and truly done, by the laborious pains of Mr. *Robert Webſter*.

CHAP. XVIII.

To Extract the Cube Root of a Number not Cubical.

You have the Diamter and Wight of Scots and Engliſh Ball, on the Scale, on the ſide of the Quadrant: Alſo the Dimenſion of one ſide Metal, both Braſs and Iron Ordnance, by which you may give Powder for Action.

I Doubt not but Men of Reaſon will think, that in Calculating all theſe Tables, I have taken great pains, ſo that you need to take the leſs: And becauſe there are many Gunners that cannot uſe their Pen, and ſome that cannot underſtand the uſe of Tables, I therefore for their help will here ſet down an Height-Rule for Ball, from one pound to an hundred pound, both in Scots and Engliſh Weight. But before this Height-Rule be made, it is needful to ſet down a Cubical Table, for except you have this Table, the Height-Rule cannot be truly made.

To Calculate this Table, it is neceſſary that you can Extract the Cube Root of Irrational Numbers; which Numbers are ſo termed, becauſe that from ſuch Numbers you cannot extract a true Cube-Root, and therefore to the Number propounded you muſt add 3, 6, or 9 Ciphers; by which you may Extract the Cube-Root without ſenſible error, as it doth appear in the Examples following.

Example.

Let it be required to extract the Cube-Root of 8302348.

Having

Having distributed the Number given into several Cubes by Points, as is directed in Chap. 8. of this. I demand the Cube-Root of 8, (the first Cube on the left hand) which I find to be 2; wherefore placing 2 in the Quotient, and 8 the Cube thereof, under 8 the first Cube, I draw a Line, subtracting 8 out of 8, the Remainder is 0, which I subscribe under the Line. This is always the first Work, and is no more repeated in the whole Extraction, (as was intimated in the third Note of *chap.* 8.); then bringing down the next Cube, (to wit, the Figures standing in the three following places of the Number propounded) which is 302, I place it after the Remainder 0, so is 302 the Resolvend; this done, having drawn a Line underneath the Resolvend, I seek for the triple of the Square of the Root, *viz.* The Root in the Quotient is 2, which multiplied by it self produceth the Square 4, the triple whereof is 12; this I subscribe under the Resolvend, in such manner, that the Figure 2 in the Unites place of this triple Square 12, may stand directly under the Figure 3, which is seated in the third place of the Resolvend, (to wit, the place of Hundreds): Again, I triple the Root 2, which produceth 6, and subscribe this triple Number 6 under the second place (or place of Tens) in the Resolvend, to wit, under 0; then drawing a Line under the Work, and adding together the said two Numbers last subscribed, as they are ranked, the Sum of them is 126 for a Divisor: That done, esteeming 30, to wit, all the places except the first, or place of Unites, in the Resolvend, as a Dividend, I demand how often the Divisor 126 is contained in 30, and not finding it once contained therein, I write 0 in the Quotient; and now because the sum of the three Numbers which ought

```
8302348(202
8
-------
0302 Resolvend.
-------
12
 06
-------
126 Divisor.
-------
 302348 Resolvend.
-------
 1200
    60
-------
 12060 Divisor.
-------
 2400
   240
     08
-------
 242408 Ablatitium.
-------
  59940
```

to

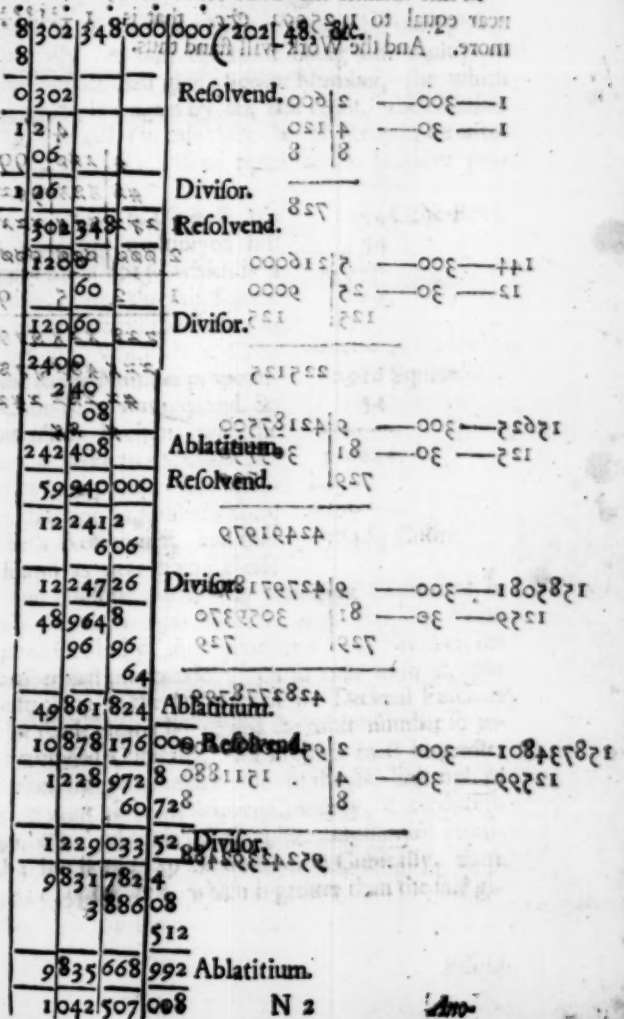
to have been produced (according as was mentioned in Chap. 8.) by the multiplication of 0, (which was laſt placed in the Quotient) amounts to 0, the Reſolvend 302, out of which the ſaid Sum ſhould have been ſubtracted, remains the ſame without alteration; wherefore having drawn a Line under the Work, I write down anew the old Reſolvend 302, and bringing down the next Cube 348, I annex it to the ſaid 302, ſo there will be a new Reſolvend, to wit, 302348. Then ſquaring the Root 20, (that is, multiplying of it by it ſelf) the Product is 400, which I triple, or multiply by 3, and ſubſcribe the Product 1200 under the new Reſolvend in ſuch manner, that the place of Unites in this triple Quadrate 1200 may ſtand under the place of Hundreds, or third place of the Reſolvend 302348, to wit, under 3. Again, I ſubſcribe the triple of the Root 20, which is 60, in ſuch manner, that the place of Unites in this triple Root 60 may ſtand under the place of Tens, or ſecond place of the Reſolvend; then adding together the two Numbers laſt ſubſcribed, to wit, 1200 and 60, in ſuch order as they are ranked in the Work, the Sum is 12060 for a Diviſor. Again, eſteeming the whole Reſolvend, except the firſt place, (or place of Unites) as a Dividend, to wit, 30234, I demand how often 1 (the firſt Figure of the Diviſor towards the left hand) is contained in 3, the correſpondent part of the Dividend; and though it be three times contained in it, yet (according to the laſt Note in Chap. 8.) I dare take but 2; for if I ſhould take 3, and proceed according as was declared in Chap. 8. a Number would riſe greater than the Reſolvend, from which ſuch Numbers riſing ought to be ſubtracted) wherefore I write 2 in the Quotient. Then multiplying the triple Square 1200 before ſubſcribed by 2, (the Figure laſt placed in the Quotient) the Product is 2400, which I ſubſcribe under the ſaid 1200, (to wit, Unites under Unites, and Tens under Tens, &c.) Alſo multiplying the triple Root 60, before ſubſcribed by 4, (the Quadrate of 2, the Figure laſt placed in the Quotient) the Product is 240, which I ſubſcribe under the ſaid triple Root 60; laſt of all I ſubſcribe 8 the Cube of the ſaid new Root 2, under the place of Unites, or firſt place of the Reſolvend, to wit, under 8; and having added together thoſe three Numbers laſt ſubſcribed, to wit, 2400, 240, and 8, as they ſtand

in Ranks in the Work, the sum of them is 242408, which being deducted from the Resolvend 302348, there will remain 59940. Wherefore the Work being finished, I find 202 to be the number of Unites contained in the Cube-Root of 8302348 the Number propounded: and because, after the Extraction is ended, there happens to be a Remainder, to wit, 59940, I conclude that the Cube-Root sought is greater than the said 202, but less than 203; yet how much it is greater than 202, no Rules of Art hitherto known will exactly discover, altho we may proceed infinitely near, as by the following Rule will be manifest.

To find the Fractional part of the Root very near.

Ternaries of Ciphers, to wit, 000, 000000, or 000000000, &c. are to be annexed to the Number first propounded; then esteeming the Number propounded with the Ciphers annexed to be but one entire Number, the Extraction is to be made according as hath been prescribed in this Chapter; and look how many Points were placed over the Number first given, so many of the foremost places in the Quotient are the Integers or Unites contained in the Cube-Root sought, and the rest of the places in the Quotient are to be esteemed as the Numerator of a Decimal Fraction; which Numerator consists of so many places as there were Points over the Ciphers first annexed: so if 8302348 were given, as before, to find the Cube-Root thereof, (according to this Rule) annex Ciphers, as you here see in the Work. And then if you prosecute the Extraction according to the Rules foregoing, you shall find the Cube-Root sought to be 202,48, &c. that is, $202\frac{48}{100}$ and more; wherefore you may conclude that $202\frac{48}{100}$ is less than the true Root, but $202\frac{49}{100}$ is greater than it; So that by annexing two Ternaries of Ciphers, to wit, six Ciphers to the number propounded, you will not miss $\frac{1}{100}$ part of an Unite of the true Root; as also by annexing three Ternaries of Ciphers, to wit, 9 Ciphers, you will not miss $\frac{1}{1000}$ part of an Unite of the true Root; and in that order you may proceed infinitely near, when you cannot obtain the true Root. The whole Operation of the said Example you have in the next Page, where you may observe, that for the more certain and easy placing, as well of the Numbers, which constitute the several Divisors, as of those which constitute the Ablatitious Numbers to be subtracted

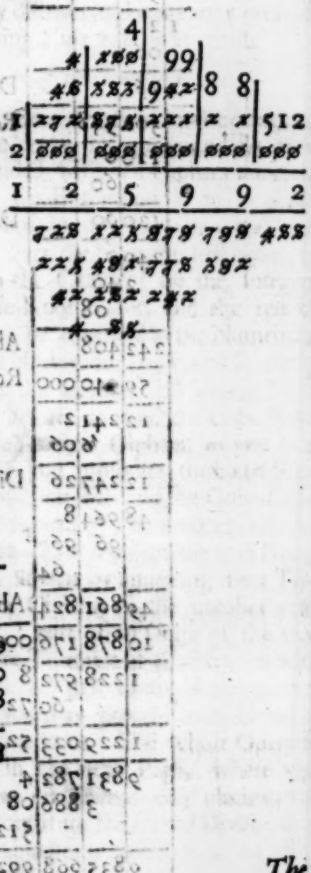
tracted from the several and respective Resolvends, down right Lines are drawn between the particular Cubes of the Number propounded, first distinguished by Points as below.



Another Example wrought by the Centuries.

In like manner the Cube-Root of 2, will be found to be near equal to 1,25992, *&c.* that is, 1 $\frac{25992}{100000}$ parts and more. And the Work will ſtand thus.

1	300	2	600
1	30	4	120
		8	8
			728
144	300	5	216000
12	30	25	9000
		125	125
			225125
15625	300	9	42187500
125	30	81	303750
		729	729
			42491979
1585081	300	9	4279718700
1259	30	81	3059370
		729	729
			4282778799
158734801	300	2	952408806000
12599	30	4	1511880
		8	8
			952423921888



The Proof of the Cube-Root.

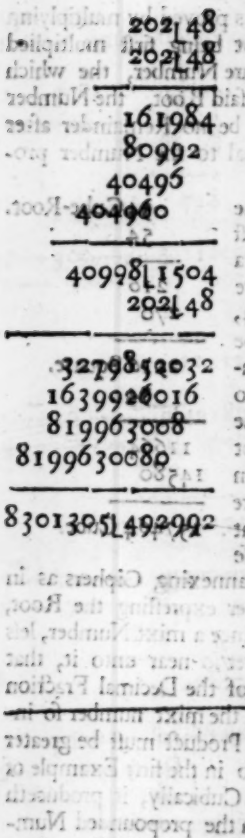
The Extraction of the Cube-Root is proved by multiplying the Root Cubically; to wit, the Root being firſt multiplied by it ſelf, the Product ſhall give a Square Number, the which Square being multiplied again by the ſaid Root, the Number ariſing, or laſt Product (in caſe there be no Remainder after the Extraction is finiſhed) will be equal to the Number propounded:

So in the Example of *Chap.* 8. the Cube-Root 54 being multiplyed firſt by it ſelf, produceth 2916, which is a Square Number, then the ſaid Square 2916, being multiplied by the Root 54, produceth 157464, which is a Cube Number equal to the Number propounded, whoſe Cube-Root was required. So that the Extraction is right, and the ſame Root found is the true Cube-Root of the Number propoſed. But when after the Extraction is finiſhed, there happens to be a Remainder, and that the Root is found as near as you pleaſe in Integers and Decimal parts, (by annexing Ciphers as in this Chapter) then ſuch mixt Number expreſſing the Root, being multiplied Cubically, muſt produce a mixt Number, leſs than the Number firſt propounded; yet ſo near unto it, that if the Figure ſtanding in the laſt place of the Decimal Fraction in the Root be made greater by 1, and the mixt number ſo increaſed be multiplied Cubically, the Product muſt be greater than the Number firſt propounded: ſo in the firſt Example of this Chapter, if 202⌊48 be multiplied Cubically, it produceth 8301305⌊49, *&c.* which is leſs than the propounded Number 8302348; but if 202⌊49 be multiplied Cubically, there will ariſe 8302535⌊49, *&c.* which is greater than the ſaid given Number.

	54 Cube-Root.
	54
	216
	270
	2916 Square.
	54
	11664
	14580
	157464 Cube.

Behold

Behold the Work



The Table of Cubes, whereby the Height-Rule is made. This Height-Rule you have on the ſide of the Quadrant-Rule, both for Scots and Engliſh Ball.

A	B	A	B	A	B	A	B	A	B
1	1000	26	2962	51	3708	76	4235	101	4657
2	1259	27	3000	52	3732	77	4254	102	4672
3	1442	28	3036	53	3756	78	4272	103	4687
4	1587	29	3072	54	3779	79	4290	104	4702
5	1709	30	3107	55	3802	80	4308	105	4717
6	1817	31	3141	56	3825	81	4326	106	4732
7	1912	32	3174	57	3848	82	4344	107	4747
8	2000	33	3207	58	3870	83	4362	108	4762
9	2080	34	3239	59	3892	84	4379	109	4776
10	2154	35	3271	60	3914	85	4396	110	4791
11	2223	36	3301	61	3936	86	4413	111	4805
12	2289	37	3332	62	3957	87	4430	112	4820
13	2351	38	3361	63	3979	88	4447	113	4834
14	2410	39	3391	64	4000	89	4464	114	4847
15	2466	40	3419	65	4020	90	4485	115	4862
16	2519	41	3448	66	4041	91	4497	116	4877
17	2571	42	3476	67	4061	92	4514	117	4890
18	2620	43	3503	68	4081	93	4530	118	4904
19	2668	44	3530	69	4101	94	4546	119	4918
20	2714	45	3556	70	4121	95	4562	120	4931
21	2758	46	3583	71	4140	96	4578	121	4946
22	2802	47	3608	72	4160	97	4594	122	4959
23	2843	48	3634	73	4179	98	4610	123	4973
24	2884	49	3659	74	4198	99	4626	124	4986
25	2924	50	3684	75	4217	100	4642	125	5000

In this Table you have ten Columns, in the firſt, third, fifth, ſeventh and ninth Columns, you have the weight of Ball, from 1 ℔ to 125 ℔ and are marked with the Letter A; and in the ſecond, fourth, ſixth, eighth, and tenth Columns, you have the Cube-Roots and Parts corſpondent to the Weight of Ball, which are marked with the Letter B; as ſhall appear in the Examples following.

CHAP.

CHAP. XIX.

The way to find the Diameter of the first-pound Ball.

NOw if any Artificial Gunner desire to make a Height-Rule or Scale to know the Weight of his Shot, by measuring the Diameter of the Ball, and by this Cubical Table: First he must know the exact Diameter of a Ball of one pound weight, of what sort of Metal or Stone he desires his Height-Rule or Scale for; the which to do, observe these Rules following.

First, Search until you find a Ball of that Metal very smooth, of any size or weight, and take the Diameter exactly of that Ball, with a pair of Callabassero Compasses. Then draw that Diameter on a piece of Paper, or plain Board, and divide it into as many equal parts as you please: then weigh that Ball exactly well, which being done, multiply the Divisions of the Diameter of the Ball Cubically, and divide that Product by the weight of the Ball; so from that Quotient of your Division, you are to extract the Cube-Root, and the Quotient is the parts of that Ball which weigheth one pound weight of that Metal.

Example.

The Ball given is a Ball of Iron, whose weight is 12 lb; and his Diameter is divided into 300 equal parts; which done, work as followeth.

300

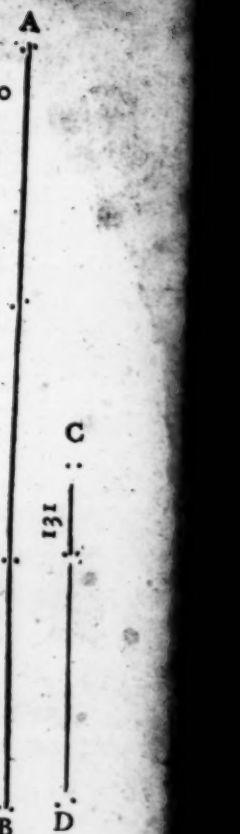
300
300
90000
300
27000000

1—300— 3 | 900
1— 30— 9 | 270
27 | 27
1197

169—300— 1 | 50700
13— 30— 1 | 390
1 | 1
51091

xx
x7 xx xx xx) 2250000
xxxxxxxx
xxxxxx

1
x 899
xxxxxx
1 3 1
xxxxxx
xx



By which I find 131 parts of the Ball given, to be the juſt Diameter of a Ball of one pound weight, of that Country-Weight. As you may ſee by the Diameters herewith annexed; the Line A B the Diameter of the Ball given, and the Line C D the Ball found for one pound.

After you have found the true Diameter of one pound Ball, you muſt divide the ſame into 1000 equal parts; or make a Diagonal Scale of the ſame Diameter of the one pound Ball, and ſo reſort to the Table of Cubical Numbers; and having a Scale of Paper or Wood ready, you may ſet the Diameter of the Ball on it, from one pound as far as the Table doth run.

And that I may make it the more plain, behold the Diameter of a Ball of 12 pound; and from that, by working as is before taught, you may have the Diameter of one pound Ball, which is here found, and true in every Condition. Thus having the Table of Cubical Numbers, wherein you find the firſt pound is 1000 in its Root, and the ſecond 1259 of the parts of one pound Ball, which is 259 parts more than the Ball of one

The Demonſtration and Diameter of a Ball of, twelve pound being given the Diameter of one pound Ball is alſo given, as in pag. 92.

A pound; which added to the Diameter of one pound, gives the Diameter of a Ball of 2 pound; which place on your Ruler, then the Table gives 1442, for the Diameter of a Ball of 3 pound; and if you take 442, and add to the Diameter of one pound Ball, you have the Diameter of a Ball of 3 pound: And thus you may encreaſe and go upward till you have a compleat Height-Rule of what heighth you pleaſe.

So making it, as you are taught, you may anſwer any Queſtion demanded of the Weight of Ball, of the Metal and Weights of the place it is made for. For all places have not one Weight, as you ſee by the Table following.

The Proof of the Height-Rule.

Now every Height-Rule for Ball, of what Metal ſoever it be made for, is proved in manner following: That when you extend your Compaſſes to the height of one pound, and with the ſame extention turn your Compaſſes, you ſhall reach 8 pound; and if you take the Diameter of a 2 pound Ball, and turn the Compaſſes about, muſt fall in 16 pound Ball; and of 3 pound to 24 pound: So that all Ball being twice the Diameter of the other, muſt carry 8 times the weight of the other.

Furthermore, By the Cubical Table, with the Diagonal Scale of the heighth of one pound Ball, you may give an account to make Height-Rules, ſhewing the Weight of Iron Ball in any Place or Country, knowing the proportion it beareth with our own Scots or Engliſh Weight: So that here it will be very requiſite, in regard ordinarily every Countrey have their own diſtinct Weights and Meaſures, to give a Catalogue of ſome ſeveral Places, and their Weights, compared with ours as you ſee, and as ſhall be further demonſtrated for the Gunner's more eaſe.

Table

Table of the Weights of ſeveral Places being compared with ours of Edinburgh.

100 pounds at *Edinburgh* maketh at

	lb.
London	112
Antwerp	108
Bollogne, betwixt 139 and	140
Catalogne	160
Cullen	102
Cureland	98
Dantzick	122
Florence	142
Lubeck	110
Lyons	120
Genua, betwixt 152 and	153
Amſterdam	100
Venetia, great Weight	106
Prague	62
Lublin	128

I ſet here for Example; There is a Gun in *Edinburgh*, meaſured by the Height-Rule, and is found to ſhoot 36 lb Ball; Now the Queſtion is, What Weight of Ball the ſame Peece doth ſhoot at *London*: And comparing the Weights together, you will find it ſtand thus.

A Rule to rectifie the Weights of divers Places with ours.

lb	lb	lb
100	36	112
		36
		672
		336
		lb 40 | 32
		16
		192
		32
		Ounces 5 | 12

And that Peece which ſhooteth 36 lb Ball at *Edinburgh*, will require at *London* a Ball of 40 lb 5 ounces Engliſh weight.

Another Example.

Likewiſe if there were a Peece at *Edinburgh*, which ſhoots 9 lb Ball; I would know what the Weight of a Ball fit for that Peece ſhall be of *Dantzick* Weight.

pound; which added to the Diameter of one pound, gives the Diameter of a Ball of 2 pound; which place on your Ruler, then the Table gives 1442, for the Diameter of a Ball of 3 pound; and if you take 442, and add to the Diameter of one pound Ball, you have the Diameter of a Ball of 3 pound: And thus you may encreaſe and go upward till you have a compleat Height-Rule of what heighth you pleaſe.

So making it, as you are taught, you may anſwer any Queſtion demanded of the Weight of Ball, of the Metal and Weights of the place it is made for. For all places have not one Weight, as you ſee by the Table following.

The Proof of the Height-Rule.

Now every Height-Rule for Ball, of what Metal ſoever it be made for, is proved in manner following: That when you extend your Compaſſes to the height of one pound, and with the ſame extention turn your Compaſſes, you ſhall reach 8 pound; and if you take the Diameter of a 2 pound Ball, and turn the Compaſſes about, muſt fall in 16 pound Ball; and of 3 pound to 24 pound: So that all Ball being twice the Diameter of the other, muſt carry 8 times the weight of the other.

Furthermore, By the Cubical Table, with the Diagonal Scale of the heighth of one pound Ball, you may give an account to make Height-Rules, ſhewing the Weight of Iron Ball in any Place or Country, knowing the proportion it beareth with our own Scots or Engliſh Weight: So that here it will be very requiſite, in regard ordinarily every Countrey have their own diſtinct Weights and Meaſures, to give a Catalogue of ſome ſeveral Places, and their Weights, compared with ours as you ſee, and as ſhall be further demonſtrated for the Gunner's more eaſe.

Table

Table of the Weights of ſeveral Places being compared with ours of Edinburgh.

100 pounds at *Edinburgh* maketh at	lb.
London	112
Antwerp	108
Bollogne, betwixt 139 and	140
Catalogne	160
Cullen	102
Cureland	98
Dantzick	122
Florence	142
Lubeck	110
Lyons	120
Genua, betwixt 152 and	153
Amſterdam	100
Venetia, great Weight	106
Prague	62
Lublin	128

I ſet here for Example; There is a Gun in *Edinburgh*, meaſured by the Height-Rule, and is found to ſhoot 36 lb Ball; Now the Queſtion is, What Weight of Ball the ſame Peece doth ſhoot at *London*: And comparing the Weights together, you will find it ſtand thus.

lb	lb	lb
100	36	112
		36
		672
		336
		lb 40L32
		16
		192
		32
		Ounces 5L12

A Rule to rectifie the Weights of divers Places with ours.

And that Peece which ſhooteth 36 lb Ball at *Edinburgh*, will require at *London* a Ball of 40 lb 5 ounces Engliſh weight.

Another Example.

Likewiſe if there were a Peece at *Edinburgh*, which ſhoots 9 lb Ball; I would know what the Weight of a Ball fit for that Peece ſhall be of *Dantzick* Weight.

Behold the Work.

℔	℔	℔
100	9	122
		9
		———
	℔ 10	98
		16
		———
		588
		98
		———
Ounces	15	68

You see that of that Weight it will be 10 pound 15 ounces, and $\frac{68}{100}$ parts of an ounce.

And so generally the Gunner may fit himself with Ball in all Places.

And as there is a diversity in the Weights of several Places, so is there likewise a diversity in the Foot: And that here it will be necessary to give a Catalogue of some several places, and their Feet compared with our Foot.

A Catalogue of the Feet of several Places compared with ours of Edinburgh.

		Foot.
100 foot of *Edinburgh* maketh—	Of the Ancient *Romans*	87|19
	Of the Ancient *Greeks*	83|14
	Of the Ancient *Babylonians*	74|38
	Of *Alexandria*	72|73
	Of the Isle *Samos*	72|73
	Of *Arabia*	81|82
	Of *London*	90|00
	Of *Paris*	82|64
	Of *Leyden*	87|19
	Of *Antwerp*	95|87
	Of *Copenhagen*	90|00
	Of *Venice*	77|60
	Of *Toledo*	100|00
	Of *Stratsburgh*	94|22

Example.

Example.

There is a Gun in *Edinburgh*, whoſe Diameter of the Bore is meaſured by the Height-Rule to be $6\frac{1}{4}$ Inches; I demand how many Inches of *London* ſhall the Diameter of the Bore of the ſame Peece be.

Inches.	Inches.	Inches.
x80	$6\frac{1}{4}$	80
4	——	$5\frac{1}{4}$ Inches.
4	x8	
——		
x6		

I Anſwer, That Peece whoſe Diameter of the Bore is $6\frac{1}{4}$ Inches at *Edinburgh*, is but $5\frac{1}{4}$ Inches of Diameter at *London*.

Another Example.

There is a Gun at *London* which ſhooteth a Ball of $6\frac{1}{4}$ Inches Diameter; I demand of how many Inches Diameter ſhall a Ball be at *Edinburgh* which ſhall fit the ſame Peece.

Inches.	Inches.	Inches.
80(0	$6\frac{1}{4}$	10(0
8	——	3
	x7	——
	3	x8
		$7\frac{1}{2}$ Inches.

I Anſwer, That Peece which ſhooteth a Ball of $6\frac{1}{4}$ Inches Diameter at *London*, ſhall certainly require a Ball to fit her at *Edinburgh* of $7\frac{1}{2}$ Inches.

Any Ingenious Gunner obſerving all the Rules that hath been deſcribed in this Chapter, may make an Height-Rule for any Metal of Ball.

For more clearing of this, I ſhall ſet here a Table of equal Diameters and different Weight.

The

The Diameters of Ball of one Country Weight to be found by equal and ſeveral Diviſions of ſeveral Metals and Stones, as they are compared with Iron.

Iron is in Proportion to		The Proportion of Iron Ball compared with other Metals and Stones.
Copper	as 8 is to 09	
Silver	as 24 is to 31	
Lead	as 16 is to 23	
Quickſilver	as 56 is to 95	
Gold	as 8 is to 19	
Tin	as 120 is to 111	
Marble	as 96 is to 43	
Sclate	as 48 is to 13	
Stone	as 144 is to 35	
Brick	as 288 is to 65	

Example.

There is a Gun which ſhooteth a Ball of Iron weighing 24 pounds; I demand what ſhall a Ball of Lead of the ſame Diameter weigh.

	lb	
18	24	23
2	3	3
		69
		34 ½ lb.

I Anſwer, This Peece ſhall require a Ball of Lead which weigheth 34 pounds and 8 ounces, which ſhall be of the ſame Diameter as was the Iron Ball of 24 pounds.

Another

Another Example.

There is a Gun which ſhooteth a Ball of Iron weighing 36 pounds; I demand what ſhall a Ball of Stone of the ſame Diameter weigh.

	lb	
4 4 4	36	4 8
4		8 ½ pound.

I Anſwer, This Peece ſhall require a Ball of Stone which weigheth but 8 lb and 12 ounces, which ſhall be of the ſame Diameter as was the Iron Ball of 36 lb.

CHAP. XX.

FOr the Gunners further eaſe, I have ſet down Tables both of Scots and Engliſh Weight of Iron Ball, from 1 lb to 100 lb; with the Diameters of the Ball both in Scots and Engliſh Inches, and parts of Inches; togerher with the Heighth of the Bores of the Ordnance that the ſame Ball ſhall fit in the like Inches: So that he may take the Diameter of a Ball, (only knowing the Weight); as alſo the Heighth of the Bore of the Peece, which the ſame Ball ſhall fit, from any Diagonal Scale of Inches, divided into Decimal parts.

Tables

Tables for Iron Ball, wherein you have the Weight of every Ball given in Scots Weight, from 1 lb to 100 lb; together with the Diameters or Height of every Ball in Scots Inches, and parts of Inches; exactly Calculated to each pound Weight above-mentioned.

A	B	A	B	A	B	A	B
1	2.2222	26	6.5833	51	8.2410	76	9.4129
2	2.7998	27	6.6667	52	8.2944	77	9.4540
3	3.2049	28	6.7480	53	8.3473	78	9.4948
4	3.5276	29	6.8273	54	8.3994	79	9.5351
5	3.8000	30	6.9050	55	8.4510	80	9.5752
6	4.0380	31	6.9808	56	8.5019	81	9.6150
7	4.2509	32	7.0551	57	8.5522	82	9.6544
8	4.4444	33	7.1279	58	8.6019	83	9.6934
9	4.6223	34	7.1991	59	8.6511	84	9.7322
10	4.7876	35	7.2694	60	8.6997	85	9.7708
11	4.9421	36	7.3377	61	8.7478	86	9.8089
12	5.0877	37	7.4050	62	8.7953	87	9.8468
13	5.2251	38	7.4709	63	8.8423	88	9.8843
14	5.3559	39	7.5360	64	8.8889	89	9.9217
15	5.4804	40	7.5999	65	8.9349	90	9.9587
16	5.5997	41	7.6627	66	8.9806	91	9.9954
17	5.7140	42	7.7246	67	9.0257	92	10.0319
18	5.8238	43	7.7853	68	9.0703	93	10.0681
19	5.9298	44	7.8452	69	9.1146	94	10.1041
20	6.0320	45	7.9042	70	9.1584	95	10.1398
21	6.1310	46	7.9623	71	9.2018	96	10.1752
22	6.2268	47	8.0196	72	9.2448	97	10.2104
23	6.3197	48	8.0761	73	9.2874	98	10.2454
24	6.4100	49	8.1318	74	9.3297	99	10.2801
25	6.4978	50	8.1868	75	9.3714	100	10.3147

In this Table you have eight Columns; in the first, third, fifth, and seventh Columns, marked with the Letter A, is the Weight of the Ball in Scots Weight; and in the second, fourth, sixth, and eighth Columns, marked with the Letter B, you have the Diameter of the Ball in Scots Inches, and Decimal parts of Inches. The Geometrical Demonstration of these two Tables is in *pag.* 54.

Tables

Tables for Iron Ball, wherein you have the Weight of every Ball given in Scots Weight, from 1 lb *to* 100 lb; *together with the Height of the Bore of each Peece answering to those Balls, given in Scots Inches and parts of Inches; Exactly Calculated to each pound weight of Ball above mentioned, the Wind being truly extracted.*

A	B	A	B	A	B	A	B
1	2.3529	26	6.8695	51	8.5993	76	9.8223
2	2.9645	27	6.9566	52	8.6550	77	9.8650
3	3.3934	28	7.0414	53	8.7102	78	9.9076
4	3.7351	29	7.1241	54	8.7645	79	9.9497
5	4.0235	30	7.2052	55	8.8184	80	9.9915
6	4.2734	31	7.2843	56	8.8715	81	10.0330
7	4.5010	32	7.3618	57	8.9240	82	10.0742
8	4.7058	33	7.4378	58	8.9759	83	10.1149
9	4.8424	34	7.5121	59	9.0272	84	10.1553
10	5.0156	35	7.5855	60	9.0779	85	10.1956
11	5.1774	36	7.6567	61	9.1281	86	10.2354
12	5.3300	37	7.7270	62	9.1777	87	10.2749
13	5.4739	38	7.7957	63	9.2267	88	10.3141
14	5.6109	39	7.8637	64	9.2754	89	10.3531
15	5.7414	40	7.9303	65	9.3234	90	10.3917
16	5.8664	41	7.9959	66	9.3711	91	10.4300
17	5.9861	42	8.0605	67	9.4181	92	10.4681
18	6.1011	43	8.1238	68	9.4647	93	10.5058
19	6.1876	44	8.1863	69	9.5109	94	10.5434
20	6.2943	45	8.2479	70	9.5566	95	10.5807
21	6.3976	46	8.3085	71	9.6016	96	10.6176
22	6.4975	47	8.3683	72	9.6467	97	10.6543
23	6.5945	48	8.4272	73	9.6912	98	10.6909
24	6.6887	49	8.4854	74	9.7353	99	10.7271
25	6.7803	50	8.5427	75	9.7788	100	10.7632

In this Table you have eight Columns; in the first, third, fifth, and seventh Columns, marked with the Letter A, is the weight of Ball in Scots Weight; and in the second, fourth, sixth, and eighth Columns, marked with the Letter B, you have the Height of the Bore of each Peece, which those Balls shall fit, the Wind truly Extracted, in Scots Inches, and Decimal parts of Inches: Which you have in the Copper Plate, *pag.* 56, 57.

Tables for Iron Ball, wherein you have the Weight of every Ball given in Englisſh Weight, from 1 ℔ *to* 100 ℔; *together with the Diameter or Height of every Ball in Englisſh Inches and parts of Inches; exactly Calculated to each pound Weight of Ball above-mentioned.*

A	B	A	B	A	B	A	B
1	1.9230	26	5.6969	51	7.1313	76	8.1455
2	2.4228	27	5.7690	52	7.1776	77	8.1811
3	2.7735	28	5.8394	53	7.2233	78	8.2163
4	3.0526	29	5.9081	54	7.2685	79	8.2513
5	3.2883	30	5.9752	55	7.3131	80	8.2860
6	3.4943	31	6.0409	56	7.3571	81	8.3203
7	3.6786	32	6.1051	57	7.4007	82	8.3544
8	3.8460	33	6.1681	58	7.4437	83	8.3883
9	4.0000	34	6.2298	59	7.4862	84	8.4218
10	4.1430	35	6.2903	60	7.5283	85	8.4551
11	4.2767	36	6.3496	61	7.5699	86	8.4881
12	4.4026	37	6.4079	62	7.6110	87	8.5209
13	4.5216	38	6.4651	63	7.6517	88	8.5534
14	4.6347	39	6.5223	64	7.6920	89	8.5857
15	4.7425	40	6.5766	65	7.7318	90	8.6177
16	4.8457	41	6.6309	66	7.7712	91	8.6495
17	4.9446	42	6.6844	67	7.8104	92	8.6811
18	5.0397	43	6.7370	68	7.8490	93	8.7124
19	5.1313	44	6.7888	69	7.8873	94	8.7436
20	5.2198	45	6.8399	70	7.9252	95	8.7744
21	5.3054	46	6.8902	71	7.9628	96	8.8051
22	5.3883	47	6.9398	72	8.0000	97	8.8356
23	5.4688	48	6.9886	73	8.0369	98	8.8658
24	5.5469	49	7.0368	74	8.0734	99	8.8959
25	5.6229	50	7.0844	75	8.1096	100	8.9258

In this Table you have eight Columns; in the firſt, third, fifth, and ſeventh Columns, marked with the Letter A, is the Weight of the Ball in Engliſh Weight; and in the ſecond, fourth, ſixth, and eighth Columns, marked with the Letter B, you have the Diameter of the Ball in Engliſh Inches, and Decimal parts of Inches.

Tables

Tables for Iron Ball, wherein you have the Weight of every Ball given in Engliſh Weight, from 1 lb *to* 100 lb; *together with the Height of the Bore of each Peece anſwering to thoſe Balls, given in Engliſh Inches and parts of Inches; Exactly Calculated to each pound weight of Ball above mentioned, the Wind being truly extracted.*

A	B	A	B	A	B	A	B
1	2.0362	26	5.9446	51	7.4414	76	8.4997
2	2.5653	27	6.0198	52	7.4897	77	8.5368
3	2.9371	28	6.0933	53	7.5374	78	8.5735
4	3.2322	29	6.1650	54	7.5845	79	8.6101
5	3.4817	30	6.2350	55	7.6311	80	8.6463
6	3.6998	31	6.3035	56	7.6770	81	8.6821
7	3.8950	32	6.3705	57	7.7225	82	8.7176
8	4.0722	33	6.4363	58	7.7673	83	8.7530
9	4.2353	34	6.5007	59	7.8117	84	8.7886
10	4.3403	35	6.5638	60	7.8556	85	8.8227
11	4.4804	36	6.6257	61	7.8990	86	8.8571
12	4.6123	37	6.6865	62	7.9419	87	8.8914
13	4.7369	38	6.7462	63	7.9844	88	8.9253
14	4.8554	39	6.8059	64	8.0264	89	8.9590
15	4.9683	40	6.8625	65	8.0680	90	8.9924
16	5.0764	41	6.9192	66	8.1091	91	9.0256
17	5.1801	42	6.9750	67	8.1500	92	9.0585
18	5.2797	43	7.0299	68	8.1903	93	9.0912
19	5.3544	44	7.0840	69	8.2302	94	9.1238
20	5.4467	45	7.1373	70	8.2698	95	9.1559
21	5.5361	46	7.1898	71	8.3090	96	9.1879
22	5.6226	47	7.2415	72	8.3478	97	9.2198
23	5.7066	48	7.2925	73	8.3863	98	9.2513
24	5.7881	49	7.3427	74	8.4244	99	9.2827
25	5.8630	50	7.3924	75	8.4622	100	9.3139

In this Table you have eight Columns; in the firſt, third, fifth, and ſeventh Columns, marked with the Letter A, is the weight of Ball in Engliſh Weight; and in the ſecond, fourth, ſixth, and eighth Columns, marked with the Letter B, you have the Height of the Bore of each Peece, which thoſe Balls ſhall fit, the Wind truly Extracted, in Engliſh Inches, and Decimal parts of Inches: Which you have in the Copper Piece herewith.

Thus having both Arithmetically, and by Tables, given Inſtructions how to make an Height or Diameter-Rule for Ball; and likewiſe having ſhown both Arithmetically, Geometrically, and by Tables, how to deduct the Wind from the Bore of a Peece, thereby to know her true Diameter of Ball; and having given Tables of the Weight of Ball by their Diameters; Therefore it follows, by the Weight of the Ball and Fortification of the Peece, that all Ordnance have their Powder either for Proof or Action.

And, as I have ſhown by the Tables, all Braſs or Iron Ordnance ought to have their Powder to their Proof; for True-Bored Ordnance, and True-Fortified, the Weight of their Ball from 1 ℔ to 8 ℔, and from 8 to 18 three quarters of their Balls Weight; and from 18 to 48, two third parts of the Weight of the Ball, and ſo infinitely.

For their Ordinary, follow the Tables where you may ſerve ſufficiently, and ſave Powder.

For Powder in Service or Action, it is to be referred to the Gunners diſcretion; and here I will give you Tables, whereby the Gunner may give Powder to Taper-Bored Ordnance, either for Proof or Action, or any hot Service, from 1 ℔ Ball to 36 ℔ Ball.

CHAP. XXI.

AS formerly I have ſhown, all Ordnance are not true-bored; therefore I ſuppoſe it will be neceſſary for the Young Gunner to know how to give Taper-bored Guns their Powder; and though they are not ordinarily in theſe Countries, yet it may happen ſometime the Gunner may be ordered to make uſe of ſuch. In my Judgment there are no Guns more fit to go in the Head of Regiments in an Army than Taper-bored Guns are: I mean not Leather Guns, by which the King and Country hath been cheated, but ſuch as they make in *Holland* of Braſs, Caſt Ordnance. Neither do I mean thoſe Taper'd Guns, with which the *Hollanders* cheat the World, being Plates of Braſs within and without, betwixt the Skins there are Bars and Hoops of Iron.

A Table

A Table of Powder for Taper-Bored Ordnance, both for Proof, Action, and Storm; from one pound Iron Ball, to 36 pound.

Iron Ball.	Proof.			Action.			Storm.		
lb	lb	on.	dr.	lb	on.	dr.	lb	on.	dr.
1	00	05	05	00	04	00	00	03	00
2	00	10	11	00	08	00	00	06	00
3	01	00	00	00	12	00	00	09	00
4	01	05	05	01	00	00	00	12	00
5	01	10	11	01	04	00	00	15	00
6	02	00	00	01	08	00	01	02	00
7	02	05	05	01	12	00	01	05	00
8	02	10	11	02	00	00	01	08	00
9	03	00	00	02	04	00	01	11	00
10	03	05	05	02	08	00	01	14	00
11	03	10	11	02	12	00	02	01	00
12	04	00	00	03	00	00	02	04	00
13	04	05	05	03	04	00	02	07	00
14	04	10	11	03	08	00	02	10	00
15	05	00	00	03	12	00	02	13	00
16	05	05	05	04	00	00	03	00	00
17	05	10	11	04	04	00	03	03	00
18	06	00	00	04	08	00	03	06	00
19	06	05	05	04	12	00	03	09	00
20	06	10	11	05	00	00	03	12	00
21	07	00	00	05	04	00	03	15	00
22	07	05	50	05	08	00	04	02	00
23	07	10	11	05	12	00	04	05	00
24	08	00	00	06	00	00	04	08	00
25	08	05	05	06	04	00	04	11	00
26	08	10	11	06	08	00	04	14	00
27	09	00	00	06	12	00	05	01	00
28	09	05	05	07	00	00	05	04	00
29	09	10	11	07	04	00	05	07	00
30	10	00	00	07	08	00	05	10	00
31	10	05	05	07	12	00	05	13	00
32	10	10	11	08	00	00	06	00	00
33	11	00	00	08	04	00	06	03	00
34	11	05	05	08	08	00	06	06	00
35	11	10	11	08	12	00	06	09	00
36	12	00	00	09	00	00	06	12	00

In this Table is four Columns, in the first, under Iron Ball is the Weight of the Ball that these Guns ordinarily shoot; in the second, under Proof, is the Weight of Powder for Proof; in the third, under Action, is the Weight of Powder for Action; and in the fourth Column, under Storm, is the Powder for Service. The right order of all Gun-Founders is, That for every 6 lb Ball the Peece shoots, they allow 1 lb for the Wind.

CHAP.

CHAP. XXII.

To find the Diameter and Length of the Taper'd Chamber of a Peece.

Moſt neceſſary. PRovide a Tamken to the Bore or Heighth of the Ball; put it on the end of an Half-Pike, and put it up till it ſtop at the Chamber or top; take that out again, having before marked the Half-Pike; then put up the Half-Pike in the Gun to the Breech, and mark the Half-Pike again; then take a piece of bowed Wire, and put it in at the Touch-hole to the lower part of the Chamber, and mark the Wire above the Gun; then hale it up till it hack at the upper part of the Chamber, and mark the Wire there again; ſo meaſuring betwixt theſe two Marks of the Wire, you have the ſmall end of the Taper-bore; then meaſuring the Diameter of the Tamken, and ſo you have the great End: Then taking the Diſtance between the marks of the Half-Pike, ſo having both Diameters and Length, (if you will) you may draw the form of a Taper'd Chamber on Paper, and extract the Wind from it, for the Cartrage going up with more eaſe.

CHAP. XXIII.

For Chamber-bored Guns.

THeſe Guns are tryed with ¼ part of their Balls weight of Powder; So that a Peece ſhooting 24 ℔ Ball, is proved with 6 ℔ Powder: For Ordinary, there is allowed for every pound of Ball 3 ounces of Powder, ſo that there needs no Table to thoſe Ordnance, for there is not many of thoſe to be found but Mortar-Peeces.

But

But certainly thoſe Peeces muſt be ancient ſince their Foundation; That *Joſephus* in his *Antiquities of the Jews* doth ſay, That there were Stones ſhot into *Jeruſalem* at the Siege, of great weight; that at one time one of theſe Stones ſhot off the Head of a Man, and carried it ſeveral Furlongs from the Body. *Chamber-bored Guns were of old as is ſuppoſed.*

As I am here to ſpeak of Chamber-Bored Ordnance, ſo I do remember that in *Holland* they uſe to bore their Guns of 6 lb Ball to 8 lb, and that there may come of theſe Guns to be made uſe of.

Now know that of Chamber-bored Guns, there are three ſorts; to wit, Firſt, Thoſe that ſhoot Iron Ball; Secondly, Thoſe that ſhoot Stone Ball; And Thirdly, Theſe that ſhoot Granadoes and Fire-Works. *Three ſorts of Chamber-bor'd Ordnance.*

Firſt, Know that it is a Chamber-bored Peece which hath two right and true Bores; the one is the vacant Cylinder, all from the Muzzle till you come to the Charged Cylinder; the Charged Cylinder is from the Touch-hole to the great Bore, called the Chamber, becauſe it is not ſo great a Bore as the other.

But if this Chamber be too long and narrow, or ſmall, to continue Powder for this ſort of Peeces, then the Ball may be delivered before all the Powder be fired, and do little Execution; For it is without Controverſy, that the vehemency of any Ball ſtruck from a Peece, is by virtue of the Powder fired in the Peece before it come out, and is rather hindred than furthered by any Powder that is fired after it is out. Likewiſe there be Chambers ſhort and wide, which may be harmful; for the Powder all firing ſuddenly, before it looſe the Ball, the ſtrength thereof many times doth burſt the Peece; Therefore it is beſt in this, as in all other caſes, a true Proportion be kept. *Things incident ought to be with diligence obſerved for fear of danger.*

CHAP. XXIV.

To know the true Proportion of the Chambers of Ordnance.

The true Proportion of Right Chambers in Peeces.

AND first of them which shoot Iron Ball; a well proportion'd Chamber for a Peece that shooteth Iron Ball, ought to be three Diameters of the great Bore long in the Chamber, and three quarters of the Diameter of the Ball, the Diameter of the Chamber: Having this Proportion, they ought to have one pound Powder for every three pound of Ball for Proof; and for Action three quarters of a pound; this being so plain, it needs no Tables.

The true Proportion of a Chamber in a Chamber-bored Peece that shooteth Stone, is once and a half the Diameter of the Ball long, and the Diameter of the Chamber is two third parts of the Diameter of the Ball: having this Proportion, one pound of Powder will serve to prove a Peece that shooteth 4 pound of Ball, and three quarters of a Pound for Action, the Ball being Stone.

Now I suppose, and I hope that I need not doubt, but hitherto there is enough written and declared to the use of great Ordnance of most sorts that are used, and how with caution they ought to be handled.

I was a Gunner when the Spanish Ships came to the Downs, in the year 1639.

And because I in my Youth have served for a Gunner both by Sea and Land, not doubting that any need Instruction that are undertakers to be Gunners, (but as aforesaid) it may be some Friends may prefer some Young Men before they be capable, even to be Gunners of good Ships, who never knew how to shoot a Gun in anger.

CHAP.

CHAP. XXV.

Therefore I will here give ſome needful Obſervations for Gunners of Ships.

1. THe firſt is, That the careful Gunner coming into a new Ship, diligently and carefully meaſure his Guns, to know whether they, or any of them, be full Fortified, Reinforced, or leſſened in Metal.

2. Then he ſhall with a Ladle and Sponge draw and make clean all his Guns within, that there remain not any old Powder, Stones, Iron, or any other thing that may do harm.

3. That he ſhall ſearch all his Guns within, to know if they be Taper'd, Chamber'd, or true-Bored, or whether they be crakt, flaw'd, or Hony-comb'd within: And finding what Ball ſhe ſhoots, to make the Weight of the Ball above the Port; that thereby he may ſet the ſame Mark or Number upon the Cartrage and Caſe, that in time of Service, thoſe who bring the Powder may not go wrong.

4. The Guns being dimenſioned and clean as aforeſaid, the Gunner ſhall take half a Ladle of Powder for every Gun, and blow them off, Sponge them well; and finding them clean, Load then the Peece or Guns with their reſpective Cartrages and Powder; which being rammed home, with a ſtrait Wad after it, then let the Ball roll home to the Wad, and ſet a Wad cloſe home to the Ball, that the Ball roll not out with the tumbling of the Ship; then muſt he Tamken that Peece at the Muzzle or Bore, with a Wooden Tamken, which he muſt Tallow with hard Tallow round about for preſerving the Powder from Water; Likewiſe make a little Tapon of Ockam for the Touch-hole, which muſt be tallowed alſo for Water, before the Leaden Apron be put over; then make your Peece faſt as occaſion beſt preſents.

5. The Peece loaded and faſt, then the Gunner is to have to every Peece 24 Cartrages, at leaſt, ready made; to wit, 12 filled, and 12 empty in ſort; Likewiſe he muſt be careful, ſo

long as the Gunner's Crew are busie with the Powder, that there be no burning Match or other Fire in the Ship; also to lay his Cartrages in Barrels or Chests in sort, that when there is occasion to be brought, it be without abuse.

Most needful, for great hurt may come by a Ball too high.

6. The Gunner must see that he sort his Ball very well, and lay every sort by themselves in several Cases, and upon every Case set the weight of one of the Shot which is in them. Also he ought to make the Bags for Hail, for the Guns above, ready betime, and fill them with Stones, Small Shot, or pieces of old Iron, which may do great damage to the Enemies Men.

7. If it fall out that any new Ports must be cut out in the Ship, the Gunner must be careful that they be above a Beam, or close by if possible; also that they be not higher or lower than the Ports before. Likewise that there be room for the Guns to play, because if one Gun should be dismounted, there might be another brought to her place: And observe, that the Carriage standing on her Truckes, the uppermost part of the Carriage must come to stand in the middle of the Port up and down, that a Man may lay his Peece as he pleaseth.

These not to be neglected.

8. The Gunner must be careful that the Powder in the Room be well covered with Hides; also that the Axtrees of the Truckes be well smeer'd with Sope; also that his Ropes, Rammers, and Sponges be ready at hand; and he must not let the Powder lie unturned above one Month, otherwise the Salt-Peter will descend to the lower part of the Barrel, which is to be feared if Men should make use of that Powder: And he must every Month draw the Ordnance, if he fear they have got any Wet or Moist to the Powder, also for fear of the Salt-Peter dissolving, which may prejudice the Peece. And he must be careful of the Candle and Fire about the Gun-Room and Powder-Room, that there come no disaster. Likewise he must keep a good Account of all Materials that belong to the Guns, as Ball, Match, and Powder, what part thereof he spends, and also what now remains, that he may give a good account what is become of them.

9. A Gunner must use all diligence before he rencounter with his Enemy, to set a Balley of Water betwixt every two Guns, that when they see conveniency, they may dip the Sponges for cooling of the Peeces, and fear of Fire remaining, which

which may do hurt: And that he be careful not to ſhoot except he hit, for it is ſure, when the Enemy ſees that he is not hurt, it gives him more courage: But to encourage Young Gunners, I will counſel them at Sea, not to uſe a Lont-Staff in Service, but firſt obſerving the way of both Ships, whether the one heave and the other ſet, or both heave and ſet together; and alſo the ſailing of the Ships, if both one way, or on ſeveral Tacks, whereby he ſhoot not in vain: Now if the Gunner have a ſmall piece of light Match, he ſtanding at the left ſide of the Peece, ſhall ſet his right foot in the Carriage, looking over the Peece, and according as he ſees occaſion give fire, and at the fire giving, retire his right foot, and before the Peece be recoiling the Gunner is free; and by trying his Dexterity, will make a good Experiment, and that he will do good Service: But if the Ball have not done to your expectation, you may help the next; for when you ſee from the Breech of your Peece to the Muzzle, and ſo to the Mark, you have a ſight of three things; ſo *Euclid* avers, that ſeeing over any three things, you have a right Line from the firſt to the third, through the ſecond; for there is no Man dare promiſe to make a good ſhot at Sea, if he have no experience of the Peece, and obſervation of the Ship's motion.

10. Alſo the Gunner muſt be ſure that there be no melted Stuff for Fire-Works done in the Ship but on Shore, for it is dangerous for a Gunner, and great hazard for Ship and Goods, yea and Mens lives: Likewiſe there may no Fire-Work be brought above in the Round-Houſe or Cabin to ſtand, for fear of ſhot, but muſt be kept below till time of need, either in the Powder-Room, or Steward-Room: By the hazard of ſuch things there hath been many and cruel Examples.

Of Neceſſaries that a Sea-Gunner ought to have for his Ordnance.

Neceſſaries that a Gunner ought to have for his Ordnance are many, and the quantity is according to the quantity and quality of his Guns; and alſo if he be in a Man of War, or a Merchant-Man, then there is difference of Proviſions, only I will here name them, let every Gunner take what he thinks

will fit, and at the Voyage end give an account what is ſpent, and what he hath, and how he ſpent that which is gone.

I leave to the Gunners own diſcretion the quantity of neceſſaries.

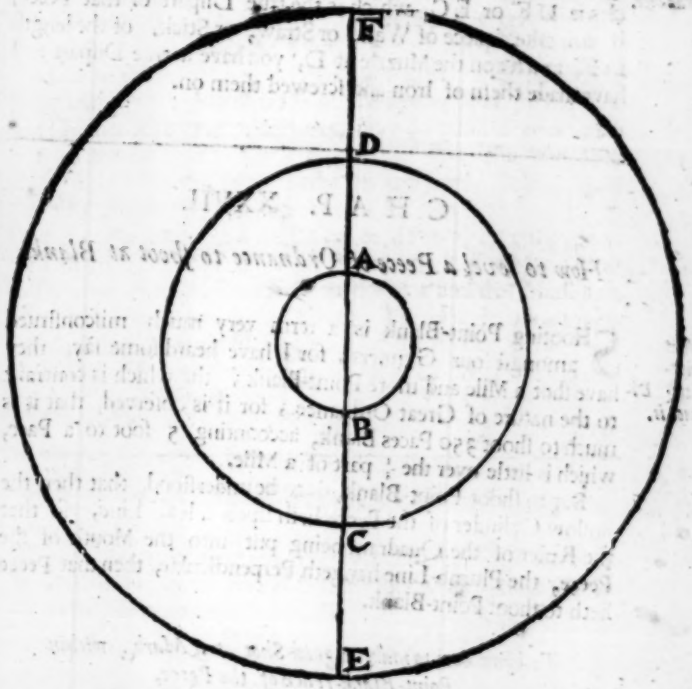
Powder.
Round-Shot in ſort.
Double-heads in ſort.
Cut Iron of foot, or foot and half long.
Wooden Tampkens in ſort.
Cartrage-Paper.
Threed, Needles, Twine and Starch.
Match.
Mallets, Hand-Spoaks, Rammer-heads, Worms, Ladles.
Sponge-heads, and Staves to place them on.
Beds and Coins in ſort.
Old Strouds for Breeching, and twice laid Stuff for Tackles.
Laſhers, double and ſingle Blocks, new Rope for Double Tackles, ſome old Strouds for Sponges, ſome Lines.
Marline, tarred Twine, Port-Ropes.
Moulds for Cartrages in ſort, Axel-Trees and Truckes.
Budg-Barrels, and Lint-Spindles, Crows, Splice-Irons.
Primes, Staples and Rings, Tackle-Hooks, Nails.
Thimbles, Port-Bands, Sheet-Lead, and Lead-Shot.
Old Canvas, Scales and Weights in ſort.
Lanthorns, Dark-Lanthorns, Powder-Meaſures.
Sope, Horns, and Prime-Irons, Height-board.
Height-Ruler and Compaſſes.

With what other Inſtruments he finds needful.

CHAP.

CHAP. XXVI.

How to Diſpart a Peece of Ordnance.



AN eaſie way to Diſpart a Peece of Ordnance. Firſt, Take the Diameter of the Peece upon the thickeſt part at the Breech with a pair of Callabaſſer Compaſſes, and likewiſe at the Muzzle at the thickeſt part thereof; then draw upon a Paper or Board both Diameters: So laying a Ruler through the

the Center, draw the Diameter, and then you may the eaſier take the Difference betwixt them.

Example.

The only way to Diſpart a Piece of Ordnance.

The Diameter of the Breech (in the preceding Figure) is E F, the Diameter at the Muzzle C D, and the Diameter of the Bore A B; ſo you ſee the Difference betwixt the two Circles is D F or E C, which is the true Diſpart of that Peece. If you take a piece of Wax, or Straw, or Stick, of the length D F, and ſet on the Muzzle at D, you have a true Diſpart: I have made them of Iron and ſcrewed them on.

CHAP. XXVII.

How to level a Peece of Ordnance to ſhoot at Blank.

What Point-Blank Diſtance is.

SHooting Point-Blank is a term very much miſconſtrued amongſt our Gunners; for I have heard ſome ſay, they have ſhot a Mile and more Point-Blank; the which is contrary to the nature of Great Ordnance; for it is obſerved, that it is much to ſhoot 350 Paces Blank, accounting 5 foot to a Pace, which is little over the $\frac{1}{7}$ part of a Mile.

But to ſhoot Point-Blank, is to be underſtood, that then the hollow Cylinder of the Peece lieth upon a level Line, ſo that the Ruler of the Quadrant being put into the Mouth of the Peece, the Plumb-Line hangeth Perpendicular, then that Peece lieth to ſhoot Point-Blank.

To know how to make a good Shot at a Mark, within Point-Blank-reach of the Peece.

The Peece lying, as is before ſhown, ſet the Diſpart of the Peece at the place required on the Muzzle, then a Ruler from the Diſpart to the Breech of the Peece; ſo turning your Peece to the Mark, you looking from the Breech alongſt the Rule to the Mark deſired, fire your Peece; and if there be nothing

nothing defective in the Peece, or Carriage, or Platform, you make a good Shot: But if the Peece lie ſo, that the Ruler of the Quadrant being in her Concavity, and the Plumb-Line cut any of the Quadrant, then is that Peece ſaid to be elevated, and will ſhoot further than when ſhe lieth level, except there be ſome Object which lieth higher than the Peece to ſtop it. And if that Peece lie ſo, that when the Ruler of the Quadrant is in her, the Plumb-Line hang without the Line of Level, then that Peece is ſaid to lie under Metal, and will not ſhoot ſo far as if the Peece were lying level, except there be a very great deſcent under the Peece.

Moreover it is certain, if Men have time, and the Object lying within Point-Blank-reach of the Peece, that the induſtrious Gunner obſerving theſe Rules, may do good Service at the firſt or ſecond Shot: for it is certain, that if a Man look along any three things or marks on one Line, then betwixt the firſt and third there is a right Line over the ſecond; ſo that if a Man look from the Breech of a Peece, over the end of his Diſpart on the Muzzle of the Peece, and to the Mark he is to ſhoot at, then the Breech of that Peece and that Mark lieth on a right Line through the Diſpart: Therefore it is imagined, the Mark being within Blank-Reach of the Peece, if the Peece be loaded and fired ſhe will make a good ſhot, all impediments being removed.

CHAP. XXVIII.

IF the Ball err, contrary to your expectation, either above the Mark or below, or on either ſide, follow the Rules following to help the next.

Rule 1.

If the Shot err too high or too low, help it thus:

When you have done as is deſcribed, and that the Shot hath carried too high as in D, or too low as in E, the Mark you ſhoot at being in C; having loaded your Peece, you are to find the

the middle of the Bore of the Peece, and the places on the Base-Ring and Muzzle-Ring corresponding, then you are to set the Dispart, so you cause traverse your Peece till you bring the Breech of the Peece A to the top of the Dispart at the Muzzle B, and the Mark C in a Line; after Fire given, you hold this for a Rule.

But the Gunner may lay his Peece very artificially, and yet the Shot may carry contrary to expectation several ways; if it be too high as in D, help it thus; having laid your Peece as at first, in the Line A B C, and found the Ball in D; then lengthen your Dispart on the Muzzle-Ring, till looking over the Peece you find A B D; this done, you are to cause lift the Breech of your Peece, till over your Peece and Dispart you find the appointed Mark C; then fire, and you will hit your desired Mark.

Observe the Copper Peece, Numb. 1.

Likewise if your Shot at first had been below the Mark, as in E; you are to load her, and bring her to her first station; and then you are to take from your Dispart so much, till you have the Line A B E; this done, you are to lower the Metal of your Peece, till you find your desired Mark A B C; fire your Peece and you do good service.

Now if the Ball should come to light on either side of the Mark, (as in the second Figure of the Copper Peece) in E to the right hand; to help the next, lay your Peece in all points as before, with her Dispart; then you are to go to the Breech of your Peece, and find at your conveniency a place on the Base-Ring, looking over the Dispart, you see the mark of the shot at E; mark narrowly that place of the Base-Ring, (with Chalk, or what you please) keeping that Mark to look over your Peece, then you cause traverse your Peece, till looking over your Mark on the Breech, your Dispart, and behold C your desired Mark in a Line; fire that Peece, and you have your desire. And if to the left hand, you may help in the same manner.

Observe the figure in the Copper Peece, Numb. 2.

But if you were to shoot at any known distance, without the Blank-reach of the Peece, upon any degree of Random, first measure the distance to the Object, and as you find it in proportion to the Blank-reach of the Peece, the same quantity you may take from the Dispart. For if your distance be ½ farther than the Blank-reach of the Peece, then take from the

Dispart

d
c
e
b
a

Diſpart ⅓ part of its length; by holding this proportion, if the Object be on a right Line from you, you will do good ſervice. Many times it falls out, that when a Gunner enters a Battery, Caſtle, or other Fortification; before he can have time to obſerve Rules, orders are given to fire ſome Ordnance; it may be in all his Life he hath not ſeen the like before that time, therefore he muſt lay his Peece by the diſcretion of his Eye and former Experience; if then his Ball ſtrike the Mark, his Experience and Diſcretion is a good Rule; but if the Ball go beſides expectation, you may help as is before taught. For if the Gunner obſerve theſe Rules cautiouſly, he ſhall find both pleaſure and profit, and have praiſe of the Spectators.

CHAP. XXIX.

The way to Shoot a Ball from a Hill to a Valley, or from a Valley to a Hill.

MAny and divers Opinions are there of ſhooting from Height to Valleys, as *Nicholas Tartaglia* in his firſt Book of *Colloquies*, and 26*th Colloquie*, affirmeth, That though the Mark be within Blank-reach of a Peece, the Ball ſhot under Metal will ſtrike above the Mark aimed at. Likewiſe one *William Claes*, in his Book called the *Practick Busketrie*, *pag.* 94. affirmeth the ſame by many Inſtances, That a Ball ſhot from a Height will over-ſhoot the Mark, though there be no impediment. But I cannot blame the *Hollander*, in regard his Country is very plain, and no remarkable Height, whereby he might have confirmed what he ſaith by practice. But I rather adhere to *Luigui Callado*; for in his *Practick manual de Arteyleria*, Chap. 8. he informs, That a Ball being ſhot from a Height, will ſtrike below the Mark; as I my ſelf by practice have found divers times.

I ſuppoſe miſtakes or truſting to other Mens Works, makes one beget another.

For in the year 1650, I was in the Caſtle of *Edinburgh*, when that Army of Rebels to our King did beleaguer that Caſtle, ſo that many times I had occaſion to ſhoot ſo far under Metal, or below the Level-Range, that I have been forced to *By Experience.*

cut the Breſt-band of the Carriage quite out, and ſo to elevate the Breech of the Peece, that it hath been ſuppoſed ſhe would fall over the Wall; and though in this caſe I durſt not coin my Peece with faſt Bed and Coin, yet always I found the Ball to hit below the Mark till I helped it.

A remarkable Inſtance.

One remarkable inſtance I had of this, in ſhooting at that Mirror of his Time for Loyalty and Gallantry, *James* Marqueſs of *Montroſs* his Head, ſtanding on the Pinacle of the Tolbooth of *Edinburgh*, with which the Enemy reproach us, as counting Loyalty a Sin worthy of Death. Now at this time I was by the Governor commanded, that there ſhould not a Gun be ſhot in the Caſtle; which I took as an ill Omen of what followed; I demanded a Reaſon for it: He told me I had too much Blood on my Head already: I being ſomewhat troubled, leſt His Majeſty, and thoſe that loved Him, both Abroad and in the Caſtle, ſhould ſuppoſe me a Helper to the Treachery, deſired the Governor to give me Orders in preſence of all the Souldiers, otherwiſe I would not deſiſt. So he ſent for me, and on the Head of the *Parade*, commanded me that no Ordnance ſhould be ſhot in the Caſtle; for if any Gunner ſhould do it, I ſhould ſuffer a Council of War. Nevertheleſs, being curious to have down the Head, which deſerved Honour above what I can write, I laid a Peece of 24 lb Ball; and becauſe I durſt not be acceſſary to any Acting, far leſs to that, I deſired *Thomas Knible*, who was Keeper of the Magazine, that he ſhould fire that Peece, after he ſaw the Governor and I gone to walk; which he did. The Governor hearing a Shot, and I in his Company, inquired who had ſhot that Gun: I anſwered, I knew not; ſo that one returned to the Wall to know who it was, and whereat he ſhot; the young Man anſwered, Sir, I thought that it was ſin in you and the Maſter Gunner to ſuffer theſe Men to fortify themſelves, and raiſe Batteries before your Noſe, and you not ſtop them, wherefore I ſhot at this, meaning the Battery.

When a Sheep is General of an Army of Lions they may be beat.

But that Providence had ordered that Head to be taken down with more Honour, I admired of its abiding, for the Ball took the Stone joining to the Stone whereon it ſtood; which Stone fell down, and killed a Drummer, and a Souldier or two, on their March betwixt the Lucken-Booths and the Church, and the Head remained, till by His Majeſty it was cauſed

caused to be taken down, and buried with such honour as was due to it.

Now any that knows the Place, knoweth that betwixt the Fore-Wall of the Castle and the Tolbooth is not a quarter of a Mile: so that it was in Blank-reach of a Demi-Cannon: Yet the Peece lying higher than the Mark shot at, shot lower than the Mark: And I am of Opinion, that Reason must give it to be so, in regard that the Parallel Line made betwixt the Breech and the Dispart, lay 8 Inches near above the Bore of the Peece; and if it carried about so far below the Mark, I am sure she perfected the Line, the Bore made parallel to the Imaginary Line above: So much for shooting from a Heighth to a Valley, which may be helped, by laying your Peece so as your Imaginary Line parallel to the Bore, direct you half a foot above the Mark, then you shall do good Service. *The Reason of their former mistakes.* *Behold the Figure AC.*

It it also to be observed, that shooting from a Valley to a Heighth, that a Ball will over-shoot the Mark, if it lie within point-Blank-reach of the Peece: Reason should give it so: for the Peece being elevated to a great Heighth, the Ball with the force and exaltation of the Powder, doth elevate above the true Line, which the Bore maketh to the Mark, in regard of the Wind or Vacancy that is betwixt the Ball and the Peece: As was found by shooting at the Castle of *Edinburgh*, where the Gunners shooting to dismount our Ordnance, most of their Shot flew over the whole Castle, till observed by the Gunners and helped. But when we come to treat of Observations of Heighths, Depths, and Distances, by the Quadrant, you will have further satisfaction.

CHAP. XXX.

To know how to make as good a Shot by Night as by Day.

AS there is none will deny, that among the many Terrifications which may be put upon an Enemy, to shoot amongst them by Night is not one of the least of them: But *Fire in the Night is terror to an Enemy.*

if you will ſhoot by Night, you muſt provide by Day, and obſerve as followeth.

Good Obſervations, if followed.

Firſt, You are to lay your Peece by Day, as is formerly taught, being loaded with Powder and Shot, as if you were to make preſently your execution at the Place. Then take a Mariners Compaſs, and ſet that on the Breech of the Peece, and looking over the Peece you ſee the Mark, and obſerve how the place bears off you, ſo that in the Night you may know how, and on what Point of the Compaſs the Place bears off you, when you are to give Fire; then take a Line and Plummet at the Muzzle of the Peece, and right over the middle of the Muzzle let the Plummet hang to the Platform; ſo you ſhall remark, or make a mark on the Line where it cutteth with the lower edg of the Bore of the Peece at the Muzzle; and likewiſe remark where the Plummet toucheth the Platform: And for your more aſſurance, you may let the Peece be fired in the Day-time at the ſame Mark; and as you find that Shot to proſecute, you may proceed as is before taught, and in the Night you may do good Service.

In the Night as by Day.

Firſt, Set your Peece as is before ſhown by the Compaſs, cauſing your Matroſs or Pioneer to traverſe the Peece to your deſire; then go to the Muzzle with your Plumb-Line, cauſing them to elevate or abaſe the Metal, till you find the Plumb-Line and Plumb fall in their former Stations: So in firing that Peece you may do good Service by Night or by Day.

But withal you muſt obſerve the diſtance to the Mark, if you be to ſhoot beyond Blank-reach of the Peece, alſo how the Wind is, whether with or againſt you, or on which ſide; for by theſe means the Ball may change her Courſe; and ſo if you have a Dark Lanthorn, that you may ſee your Compaſs and Plumb-Line, obſerving all theſe things, you may ſhoot by Night as well as by Day.

But to know whether you ſhoot right in the Night or not.

To be ſure you will ſee where your Ball lights.

It ſhall be requiſite to take ſome Butter or Tallow, and melt them in ſome Kettle, wherein you ſhall dip your Ball that is to be ſhot, and roll the ſame Ball in fine Powder, that the Powder may ſtick faſt to it; and when you have done, put home

home the Powder in your Peece; and obſerve you put no Wad betwixt the Powder and the Ball; ſo when you give fire, the Ball will flame as a Candle; and where the Ball doth light, the mixture will fly on the Object, by the light whereof you will ſee whether you have hit the Object or not.

CHAP. XXXI.

To know how far any Peece will ſhoot at any degree of Random.

THis taſk is ſo difficult as there are Proportions of Ordnance, yea it will alter by the alteration of Weather; likewiſe if the place lie higher, the Peece ſhall ſhoot farther over a Valley at the ſame Random, than ſhe ſhall from a Valley to a Heighth; for theſe Reaſons, I have found none that ever made Tables for great Ordnance, that would or could make them good on all Accounts and all Degrees.

Uncertain to find exact truth in Random Tables.

Now the only Rule by which a Gunner may know how many Paces his Peece will ſhoot, in elevating from Degree to Degree, is to take good notice how far ſhe ſhoots Point-Blank, as alſo Horizontal with the Metal; which Diſtance being marked to be ½ part, or a half, or ¾ parts farther than Point-Blank, then hath he a convenient Proportion to work by, and to find his deſire reaſonably near.

Example.

There is a Demi-Cannon ſhoots Point-Blank 200 Geometrical Paces, and Horizontal with the Metal 400 Paces, this holds proportion as 2 to 1, the one half leſs: Therefore ſay by the Rule of Three, As 2 is to 1, ſo is 200 to 100 Paces, that this Peece ſhoots farther at every Degrees elevation. Yet not wholly through the Table, for there is a rebating in every Degrees elevation: Now to find this, you ſhall yet divide 100 by 44, and you have 2 ⅓: So as 3 times 11 is 33, and 11 is 44; therefore when you deſire to make this Table, take

take 2 from 100 there remains 98, which added to 200 makes 298; then take 2 from 98, and there remains 96, which being added to 298, giveth 394: This is the first and second Degree elevated; this continues till 35 Degrees elevation, where you have 44; and you have for 35 Degrees elevation 2400 Paces; then the addition is 28, and the rebate of every Degree 3; by which you may make this Table following: and in doing so with all others you have your desire.

This Table I had from William Clash *in his Practice of Gunnery.*

A Random-Table for a Demi-Cannon to 45 Degrees.

1	298	16	1528	31	2308
2	394	17	1594	32	2344
3	488	18	1658	33	2378
4	580	19	1720	34	2410
5	670	20	1780	35	2440
6	758	21	1838	36	2468
7	844	22	1894	37	2493
8	928	23	1948	38	2515
9	1010	24	2000	39	2534
10	1090	25	2050	40	2550
11	1168	26	2098	41	2563
12	1244	27	2144	42	2573
13	1318	28	2188	43	2580
14	1390	29	2230	44	2584
15	1460	30	2270	45	2585

This is now a brief way of making a Table of Randoms for a Demi-Cannon, which may be done in like manner for any Peece of Ordnance whatsoever; first knowing the true Distance she shoots at Point-Blank, and the Distance she shoots lying Horizontal by the Metal, compute Difference, and work as before, you have your desire.

As this Table is for a Demi-Cannon, so there must be one for every sort of Ordnance the Gunner makes use of; And he shall hardly find truth.

CHAP.

CHAP. XXXII.

The Geometrical Quadrant, with the Uſes in Meaſuring Diſtances, Heights, and Depths, and Diſtances moſt uſeful for a Gunner.

Firſt,

To meaſure the Height of any Tower, Wall, or Caſtle, or any other Body, ſtanding on a Plane, if you have acceſs to it, by the Gunter's *Quadrant.*

SEt the Ruler of the Quadrant ſo to your Eye, that you ſee through the Sights, from the place where you ſtand, the mark you deſire to obſerve; then note what part of *Umbra Recta*, or *Verſa*, your Thread cuts, and you ſhall find the Height in this manner.

1. If the Thread of the Plummet fall on 100, then is the Height deſired equal to the Diſtance betwixt the Obſervers foot, and the Ground or Root of the thing obſerved.

2. Otherways, if the Thread fall on the parts of *Umbra Recta*, or Right Shadow, then is the diſtance betwixt the Obſervers foot and the ground of the thing obſerved, leſs than the Height of the Body obſerved, according as the parts cut off Right Shadow by the Thread is to 100; Therefore uſe the Rule of Proportion, otherwiſe called the Rule of Three, and ſet the parts of Right Shadow in the firſt place, cut by the Thread or Plummet-Line, and the 100 in the ſecond, and the Diſtance you are from the Root, or foot of the Mark, in the third, and the fourth place will ſhew the deſired Height; as you may ſee in the Example following.

Concluſions and Obſervations done by the Quadrant.

Example.

Suppoſe the Thread to fall on 25 parts of *Umbra Recta*, and the diſtance betwixt your Foot and the Wall be 30 foot: Then ſay, as 25 parts of Right Shadow is to 100; ſo is

30

30 foot the distance given, to 120 foot the Heighth required: to which you must add the length betwixt the Observers Eye and the Ground.

3. But if the Gunner cannot cipher, then do this; Go so far back or forward, till you see the Mark desired, and that the Plummet-Line of your Quadrant (being still observing) fall on the parts of Right Shadow: And know that if the Line fall on 100, the Distance is equal to the Heighth: If the Line fall on 75 parts, then the Distance is three quarters of the Heighth; if it fall on 66 ⅔ parts, then is the Distance ⅔ parts of the Heighth; if on 50 parts, the half of the Heighth: if on 33 ⅓ parts, one third part of the Heighth; and if on 25 parts, one quarter of the Heighth: by which you may conclude the Heighth of what you observe.

4. But in observing, if the Thread fall in parts of *Umbra Versa*, or Contrary Shadow, then know that the Distance of the Ground to the Place observed, is more than the Heighth of the same: And the Proportion is, as 100 parts is more than the parts cut off the Contrary Shadow; so is the Distance from the Mark, unto the Heighth of the thing observed.

Example.

Suppose the Thread to fall on 25 parts of *Umbra Versa*, and the Distance betwixt your Foot and the Wall be 300 foot; Then say, As 100 parts is to 25 parts of Contrary Shadow; so is 300 foot the Distance given, to 75 foot the Heighth required. To which if you add the Distance betwixt the Observers Eye and the Ground, you shall have the true Heighth.

5. And if you cannot Cipher, then go so far backward or forward, always seeing the Mark desired, till the Thread fall on what parts of Contrary Shadow you would have it; and if it be 100, then is the Distance and Heighth equal; if it fall on 75 parts, then is the Distance one quarter more than the Heighth; if it fall on 66 ⅔ parts, then is the Distance one third part more than the Heighth; if the Thread fall on 50, then is the Distance one half more than the Heighth; if it fall on 33 ⅓, then is the Distance ⅓ more than the Heighth, if on 25, then is the Distance three quarters more than the Heighth:

Ever

Ever adding the length from your Eye to your Foot, then you ſhall certainly have the true Height.

6. This manner is uſed to meaſure the Height of any thing, whereto you may have acceſs: If it were that you muſt meaſure the Height of a Wall, or any other thing ſtanding on the ſide of a River, then you muſt have two Obſervations, in manner following: Firſt, Meaſure the diſtance from your Station to the ſide of the River; being come to the brim of the Water, ſtand perpendicularly upright, draw down the brim of your Hat before your Face, till you looking by the brim of your Hat, ſee the Foot or Root of the place you would meaſure; then turn your ſelf about, obſerving in all things your geſture, till you ſee on that ſide of the River where you ſtand, ſome Hill, Down, Houſe, or any other Mark; thus you ſhall meaſure with your foot the diſtance to it, and then work as is before ſhown.

Secondly;

To meaſure the Height of any thing ſtanding on a Plane from you, when you have no acceſs to it, or were hindred by the Enemy to come near it.

1. To this Work you muſt have two ſeveral Obſervations, as followeth: Put the Ruler of the Quadrant to your Eye, in ſuch manner, that through the Sights you ſee the Mark deſired; take notice then what parts of Contrary, or Right Shadow is cut by the Thread or Plummet-Line, and then where you ſtand ſet up a Staff; then you are to go a remarkable diſtance backward or forward, and take there your ſecond Station; and obſerve your Mark as before; then note well what parts of Contrary or Right Shadow your Line cutteth; note that alſo down: Now if it be ſo, that in both your Stations the Plummet-Line hath fallen on parts of Right Shadow, then deduce the leſſer from the greater, and keep the Difference: Then ſay by the Rule of Three, As the Difference in the parts of *Umbra Recta*, is to 100 parts in the Quadrant; So is the Diſtance between the two Stations to the deſired Height of that Body: But it is to be under-

To know how far, or what Diſtance you are from the Enemies Forts, or Strengths, is moſt neceſſary for a Gunner.

underſtood, that you muſt not forget to add the Height of your Eye from the Ground.

Example.

In the firſt place, when you find the Thread fall in 25 parts of the Right Shadow, and in the ſecond on 50; then let the diſtance betwixt the ſtations be 30 foot.

Say then by the Rule of Three; As 25, the difference of the parts of Obſervation, is to 100 parts of the Quadrant; So is 30 foot the diſtance of the Stations, to 120 foot the Height required; to which add the Height of your Eye.

2. But if at one Station (or poſſibly at both Stations) the Thread falls on parts of Contrary Shadow, then the parts muſt be converted to parts of Right Shadow, as ſhall be ſhown in the following Example.

Example.

Experience is the beſt School-maſter.

Suppoſe there were placed ſome Guns on the top of a Hill, as in the Figure by A; by which the Gunners in the Valley B have a great deal of loſs and trouble; wherefore order is given to one of them, to do his endeavour to diſmount theſe Peeces at A: Now to do this with underſtanding, and what haſte convenient; Firſt, He muſt know the height of the Hill A D, with the diſtance B D: Then he may by Prop. 47. of the firſt Book of *Euclide*, find the length of the Hypotenuſal Line A B; to be aſſured how many degrees of the Quadrant his Peece muſt be elevated to the Mark.

Take for Example.

We ſay that the firſt Station obſerved, the Thread fell on 25 parts of Contrary Shadow, and at the ſecond on 90 parts of Right Shadow; then you cannot take 90 parts from 25 parts; therefore you muſt alter the 25 parts of Contrary Shadow to parts of Right Shadow, in manner following: Multiply 100, the one ſide of the Quadrant by it ſelf, and you have 10000; this you divide by 25 the parts of Contrary Shadow, and you have in the Quotient 400 parts of Right Shadow,

dow, which is equal to 25 parts of Contrary Shadow; then take 90 parts from 400 parts, there remain 310 for the Difference: Alſo let the Diſtance betwixt the two Stations, from B to C, be 200 foot: Then ſay by the Rule of Three; As 310 is to 100 parts in the Quadrant; So is 200 foot the Diſtance of the Stations, to 64 $\frac{16}{31}$, which is very near 64 $\frac{1}{2}$ foot, the Height of the Hill A D: We ſhould now ſhew the way to find the Diſtance A B and B D; that thoſe who cannot cipher, may underſtand this.

Thirdly;

Therefore we will give one Example or two, that they may do ſuch without Arithmetick.

Theſe muſt ſearch out their Stations, in which the Thread may fall on all ſuch parts of the Right and Contrary Shadow as they deſire; which is eaſy to be done, if they go diſcretly forward or backward, and meaſure the Diſtance betwixt the Stations, till the Thread fall where they deſire.

1. If the Thread fall at the firſt Station upon 100, and at the ſecond on 50 parts of Right Shadow, then is the Diſtance half the Height.

2. Or if the Thread fall at the firſt Station upon 100, and at the ſecond on 66 $\frac{2}{3}$ of Right Shadow, then is the Diſtance betwixt your Stations one third part of the deſired Height.

3. And if the Thread fall at the firſt Station on 100, and at the ſecond on 75 of Right Shadow, then is your Diſtance juſt one quarter of the deſired Height.

4. Likewiſe if at the firſt Station the Thread fall on 100, and at the ſecond on 66 $\frac{2}{3}$ parts of Contrary Shadow, then is the Diſtance half the Height.

5. Or if the Thread fall at the firſt Station on 100, and at the ſecond on 50 parts of Contrary Shadow, then is the Diſtance equal to the Height deſired.

6. The ſame it ſhall be, if at the firſt Station the Thread fall on 50 parts of Right Shadow, and the ſecond on 66 $\frac{2}{3}$ of Contrary Shadow: But ſtill remember to add the Height of your Eye above the Ground.

Fourthly;

To measure the Distance to any place, or the Breadth and Length of any Plane or Water.

By what hath been said before, it appears plainly that in the measuring the Height of any thing, there must be once a known Distance, to wit, some length of the Plane whereon the Height is erected: Likewise in measuring any Distances, as the length of a Field, it is very necessary to know the Height of something thereby; which may be easily done: for if you were to measure the Distance to a Fort, Battery, Trinal, or Bulwark, which you desire to know; if the Distance be not great, in that case you need know no Height but your Eye from the Ground where you stand; But if the Distance you would measure be great, then it is needful to have a known Height to stand upon, which Height you must add to the Height of your Eye, which may be done with a Plumb-Line, whose Marks you know: Then work as followeth.

Example.

Take for Example, that you desire to measure the Distance from B to D; then turn the Center of your Quadrant to your Eye, and observe through both your Sights the Point D; remark well what part of Right or Contrary Shadow the Thread cutteth; If it happen to fall on 100 parts, then ought the Distance to be equal to your Height: But if the Thread fall on parts of Contrary Shadow, which in such Cases is ordinary, then is your desired Length more than your known Height, so much in proportion as 100 is more than the parts cut of Contrary Shadow, which the Line sheweth. Therefore say by the Rule of Three; As the parts of Contrary Shadow, which the Plumb-Line sheweth, is to 100; So is the known Height unto the Distance required.

Example.

Example.

The Thread cutteth 1 $\frac{1}{2}$ parts of Contrary Shadow, and the Height from the Eye to the Ground is 5 foot: Then work as followeth, and you will find the length B D to be 375 foot.

1 $\frac{1}{2}$	100	5
		3
		15
		100
		1500

Facit 375 foot.

Now having the Perpendicular A D, and the Base B D, you may easily find the Hypotenusal A B, to be near 380 foot: But here you are to extract the Square Root, for *Euclide* in the 47*th* Prop. of the first Book of his Elements, hath proved by Demonstration, That in Right-Angled Triangles, the Square which is made of the side subtending the Right Angle, is equal to the Squares which are made of the sides containing the Right Angle. Where if two sides be given, we may find the third side thus; in the Right-Angled Triangle A D B, you have A D 64 $\frac{1}{2}$ foot, and you have the Base B D 375 foot; whose Squares being added, and the Square-Root extracted, you shall have the Square-Root near to be 380 $\frac{1}{2}$ foot for the Hypotenusal A B: For Extracting the Square Root, it is described in Chap. 6, and 7.

This I have done for the use of Young Gunners, that when occasion may present, they may lay their Peeces at a reasonable Degree, thereby to come near the Mark at the first Shot; And always may observe a greater distance from a Height to a Valley.

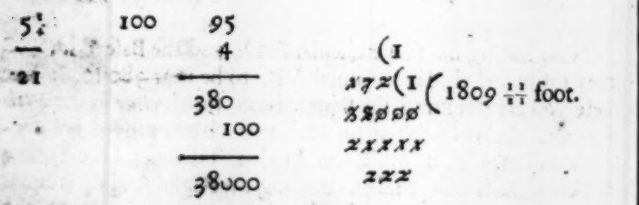
Example.

There is a Castle, as the Figure sheweth, and in the Bat-

tery

tery there lies a Peece of Ordnance; If it were desired of the Gunner to know if this Peece might be of service to dismount the Peece in the Battery C: Now the Gunner must desire time to measure the Distance from him to the Battery C; whereby he may the more assuredly Answer.

Then shall he take a Line and measure the Height A B; then standing at A, shall take the Quadrant with the Center to his Eye, and beholding through the Sights the Mark C, Remark narrowly the parts cut by the Plumb-Line, which is without fail parts of the Contrary Shadow: Then say, As the parts of Contrary Shadow are to 100; So is my Height from the low Battery to the Distance required. Let the Height A B be 95 foot, and the parts of Contrary Shadow 5 ¼, and you will find the *Facit* to be 1809 ½ foot, or 362 Geometrical Paces very near.



But if you please to reduce the Distance to Paces, divide the Quotient by 5, for 5 foot make a Pace, and you have as aforesaid.

This is so clear, that I think any Gunner may perceive, that if he be in the Battery C, elevate his Peece two Degrees above the Level, that then he might do good Service, and by once firing, if the Ball go beyond expectation, you may help the second.

Necessary Observations for Gunners either by Sea or Land.

The like may the Gunner in the Battery B do, and also the Gunner in the Battery A to C: and so each to other, for they have double Advantages of the Gunner at Sea, except he be lying in a River; and let his Ship lie never so still, so long as she is a-float, she hath ever a Motion, nevertheless the Observant Gunner in a Ship may do good Service.

For I my self in the year 1652, or 53, being forced from *Scotland*, when the War began betwixt the States of *Holland*, and

and the (then) State of *England*; and as many better than I were in neceſſity, I put my ſelf in a Frigot of *Zerveer*, one *Jacques Wolfes* Captain, I ſerved there for a Gunner, and in our Voyage to *Shetland* to bring home the *Holla's East-India* Fleet, we met with a Storm, where we loſt above 20 Sail of our Fleet, our Ship was called *Prince Rupert*; but with this Ship we were forced to come to Anchor betwixt *Fulla* and *Shetland*, and by providence road the Storm out; when we had fair Weather, we went to *Braſa Sound* in *Shetland*, and there riding at Anchor with three Ships of our Fleet: the Commander or Corporal of the Souldiers and I fell at Diſpute concerning his Men, that they could not ſhoot at a Mark; whereupon he told me, That I could not ſhoot ſo well with a great Gun, as any of them did with their Muſquet; at laſt I wagered with him that I would ſhoot as near with a great Gun, as he himſelf with a Muſquet, whereupon we agreed, (the Wager was two Rix Dollars): I ſent the Quarter-Maſter to our Captain, who was aboard one of his Conſorts at Dinner, for liberty to ſhoot; which was granted: The Mark we were to ſhoot at, was the Buoy of the Anchor of the ſame Ship our Captain was aboard of; ſo that we had the four Captains for Judges: I brought a Sacker-Cut, from the breaſt of the Steerage to the Main Maſt; I diſparted and loaded her, and ſet her to the Port, I ſet her to the middle Port of the Ship; then we were at a Conteſt who ſhould ſhoot firſt; I gave him that priviledg: So after he ſhot, he found he came not near by three yards, as it was alledged; and that he might be better pleaſed, I gave him liberty to ſhoot again, where he made little mends: Then I laid my Gun to the Port, and obſerving the ranging of the Ship, I gave fire at my conveniency, and ſtrook the Buoy, which lay about 150 paces from us; there are Men here in *London* that did ſee it. I ſay, good Service may be done aboard a Ship, if the Gunner be cautious. And by this I would have you know, that I would have Gunners to conſider, that the middle of a Ship is the only place for to make a good ſhot, though by accident there may be ſome made either afore or after; as I will give an Example.

This is true, and can be witneſſed.

Example.

Example.

In the Figure, Numb. 133. Suppose there is a Ship in a River or smooth Road a pretty distance off, as this Ship E F: The Gunner is demanded if he could do any good Service with his Guns at the Battery on the Shore G, which only could wrong them.

The Peece he is to use here is a Demi-Cannon, which shoots Point-blank 200 *Paces.* This you must consider, could not be answered, till he knew what distance he was off; therefore he must observe as followeth: First, with a Lead-Line measure the length from your Topmast-Head to the Water, as from E to F; then go to the Topmast-Head in F, and observe with the Center of your Quadrant to the Eye, that through the Sights you see the Battery G, and in all things doing as in the Battery A for clearing.

Example.

Let the Height from the Water to the Topmast-Head be 90 foot, the parts of Contrary Shadow 5; so set it on the Rule as followeth.

5	100	90
	90	
	9000	

1800 foot.

Which is 360 Geometrical Paces.

At 2 *Degrees the Demi-Cannon shoots* 394 *Paces.* Suppose the Gunner in the Ship had a Demi-Cannon, which shooteth Point-Blank 200 Paces; Therefore may the Gunner conclude to elevate his Peece 2 Degrees, and thereby at the first shot be pretty near the Mark; by which he may help the second: Even so may the Gunner in the Valley at the Battery G, observe to do good service on the Ship E F: Likewise the Gunner in the Battery A, may do good Service every-where round about, if he observe what is before set down: Nevertheless my desire is to set down another Example of observing by the Cross-Staff.

Example.

Example.

It is desired to know the Breadth of the Bulwark A B C: First, You are to observe the Distance to the same, as from D to B, which we suppose to be 750 foot: Take the Cross-Staff as E F G, having thus on the end of your Staff a Cross, as F G, at such distance as you may see by the Transom F in C, and G in A; then divide the length of your Staff in as many equal parts as you please: As here let be 15 parts, and the Cross F G, we make 7 of the same parts: Then say by the Rule of Three, As 15 parts, the length of the Staff, is to 750 foot E B; So is 7 parts, the length of the Cross, to 350 foot for the Bulwark A B C. Do the like with all others, and give good heed to the following Questions and Answers, which are useful for all Commanders, Captains, or practised Gunners, as well in Offensive as Defensive Service by Sea or Land.

The Breadth or Length of a Curtain or Bulwark is all to be done in one manner.

If a Man were on the top of a Rock or Hill, on the side of a River, and on the other side saw a Tree, and would know the distance over to that Tree, as the Figure C A B: To do this you have two Observations, the one is the Line of Level; then going on a Right Line from A to C, you observe, and find the Thread cut 54 parts of Right Shadow; then measuring your distance A C, and finding it 63 foot, you follow the Ground-Rules, 54 gives 100, what 63 foot Difference of Stations?

54—100—63

100

6300

100—25—400

25

100|00

T CHAP.

CHAP. XXXIII.

Questions for the Practice of what hath been formerly taught.

Question 1.

WHen a General with his Army hath besieged a strong Fort, Castle, or Town, and hath secured his Army by intrenchments, and hath taken notice of the most fitting places for Approaches: Now the Question is to the Gunner, How near they may approach the place with Batteries, and at what Distance the Cannon will do the best service, that there they may be planted and made.

Answer.

If I were to answer, I would desire to approach as near as it were possible to come, and to plant the Batteries about 100, and some 50 foot from one another; and if it were possible even to the Counterscarp: not only thereby to give the place most damage by the Guns, but also to frustrate the Enemy from sallying out, as likewise to do them most prejudice at their Casements, to Guns and Gunners, by which they might be forced not to dare to shew a Head above the Wall.

Question 2.

This Resolution is good, but very dangerous to perform; for as the Proverb is, It is dangerous to chase a Dog out of his Nest; for if there be a brave Enemy within, how could you approach so near, but it should cost many a brave Souldier his Life?

Answer.

As it is without Controversy, where Carpenters work there must fall Chips; but that will never cool the Courage of a brave generous Spirit, ever considering, where-ever we are, we are in the Hand of God; yea, the danger is not in all places alike, for if you be where there is Earth enough to work, there you begin to cast up Trenches and Mounts against the Town to save your selves from harm; for the higher the Earth

is,

is, the deeper is the Trench to be made, to save you from the sight of the Enemy.

Question 3.

When you are approach'd so near the Enemies Strength, that the Cannon is to do service, Whether should you chuse a Bulwark or a Curtain, for your storm-place to play upon?

Answer.

That must be according to the greatness of the place; if the Bulwarks be of great distance one from the other, in that case I would rather chuse a Bulwark than a Curtain, there to make my Breach, thinking that I should come sooner to my advancement there, because the Bulwark is better fortified than the Curtain, and is a principal Strength: And if you make your Breach for Men to enter, you find them sometimes cut off, so that you may begin to fortifie there anew, where you are as it were in the Enemies Bosom; this occasion you have not in a Curtain. See Capt. *Hexham.*

Question 4.

If you did storm this Bulwark, and found there some Guns that before you had not seen the like, and that you must presently use them against the Enemy, and know not what Ball they shoot: What is the quickest way to find their true Powder and Ball?

Answer.

If the Peece be left loaded, she must be drawn; for the Enemy in policy might so leave a Peece, on purpose to split about their Ears that take her: When drawn a piece of bowed Wire being put in at the Touch-hole down to the bottom of the Concave, upon the Metal mark that Wire with a Knife; hale the Wire up till it back on the upper part of the Metal in the Chamber, and mark as before your Wire; take the distance betwixt the two Marks, and that is the Diameter of the Bore: And see if it be the Diameter of the Bore at the Muzzle: if you find her a true-bored Peece, then take your Compasses, and extend them to the length betwixt the lower mark and the back of the Wire; this Extention being taken on the Scale of Powder gives you her Powder; and extending your Compasses betwixt the Marks, lay that to the Height-Rule, and you will have the Height of the Ball: Otherwise finding the Weight of the Ball, resort to the Table of Pow-

der for that Fortification, and where you find her Weight of Ball, you will find the Weight of Powder for that Peece; for having the Diameter of the Bore and one ſide Metal, double the one ſide Metal, and add the Bore to it, you have the Diameter of the whole Peece: Then ſay, As 7 is to 22; So is the Diameter of the Peece to her Circumference: And having one ſide Metal at the Breech and Muzzle, you have a Diſpart: So preſently you may do good Service.

Queſtion 5.

When you have the Diameter of the Bore of a Peece, How do you know what Ball will ſerve that Peece to ſhoot, and neither be too high, thereby to hurt the Peece; neither too low, to miſcarry by reaſon of the too much Wind?

Anſwer.

As it is convenient the Ball be ſomething lower than the Bore of the Gun that it ſerves for; and ſome have thought fit to declare one quarter of an Inch to be ſufficient Wind to all Balls; and others have declared, that a twentieth part of the Diameter of the Ball, is a ſufficient Wind for all Guns: I hold that quarter of an Inch to be altogether abſurd; becauſe except a Man can give the true Demonſtration, as you are taught, and is ſet forth in *pag.* 42, to 52. he ſhall never know how to extract the Wind betwixt the Bore of a Peece and her Ball. For if you pleaſe to try for fancy; A Cannon of 8 Inches in the Bore, ſhall have the Wind for her Ball $\frac{1}{11}$ part of the Diameter; as alſo a Baſe of two Inches in the Diameter of the Bore, hath but $\frac{1}{11}$ part of the Diameter of the Bore; for if a Peece of 1 lb Ball ſhall have proportionable to 9 lb Ball, ſhe would have no Wind at all; and if a Gun of 63 lb Ball had proportionable Wind as a Gun of 9 lb Ball, ſhe would have too much by $\frac{1}{11}$ part; behold the Demonſtration, *Folio* 102. and a Peece of $4\frac{1}{4}$ Inches in the Bore, hath juſt $\frac{1}{11}$ part of the Diameter of her Bore, for the Wind to her Ball: which will never ſtand as a general Rule, except it be Geometrically demonſtrated, where you will find the Height of the Cannon-Ball juſt $\frac{21}{24}$ parts of her Bore, the ſmall Ball $\frac{17}{24}$ parts, and the other $\frac{11}{24}$ parts: Wherefore I aver, all that hath been writ to this purpoſe, is but Suppoſition and no real Rule; but Geometrically you have your deſire, and need not to follow any other Rule for extracting the Wind to find the True Ball.

Queſtion

Question 6.

When you have obtained Geometrically the true Diameter of a Ball to fit a Peece, the Question is, How shall you know the weight of that Ball, it being Iron?

Answer.

Some receive this by a common Opinion, that 4 Inches Diameter of a Cast Iron Ball is 9 ℔ *Averdupoise* Weight, as you may see by Dr. *Weybard's Tactimetria*; wherefore I say that is the most certain Rule. Now if 4 Inches Diameter weighs 9 ℔; What shall two Inches weigh? You will find the work stand thus.

Inches.	℔.	Inches.	
4	9	2	(8 (℔.
4	8	2	72 1 and $\frac{8}{64} = \frac{1}{8}$
16	72	4	64 Which is 2 ounces.
4		2	
64		8	

And it is a general Rule; behold you see a Ball of 2 Inches Diameter weigheth 1 ℔ 2 ounces: If you hold this for a Rule, you may work and correct all Tables of this kind that are made in *England*: Likewise, I say, you may find the weight of any Iron Ball thus; Say,

Inches.	℔.	Inches.	
2	$1\frac{1}{8}$	8	
2	9	8	
4		64	72
2		8	4608 (72 ℔.
8		512	644
8		9	8
64		4608	

It hath been ever observed for good, that the Tables of Mr. *Norton*,

Norton, *Smith*, and *Nye*; and therefore Capt. *Sturmy* in his *Magazine for Mariners*, doth follow the same Rule, and gives us the same Tables of Mr. *Nye*, as he supposeth refined: for he sayes, Two Inches and a quarter of Ball, weigheth 1 lb 5 ounces: I will let you see the Error.

Inches.	lb.	Inches.
$2\frac{1}{4}$	$1\frac{5}{16}$	4
9	21	4
9		16
81		16
9		96
729		16
		256
		16
		1536
		256
		4096
		21
		4096
		8192
		86016

12
1212 (6
86016 (112 (lb ounces.
72888 (16 7 6
722
7

Now here a Ball of 4 Inches Diameter by his Tables, weighs but 7 lb 6 ounces: But I praise Mr. *Norton*, who says, We must not expect truth from his Tables. But Capt. *Sturmy* affirms his Translation of *Nye* to be truly Calculated: if they be true, I must be quite wrong.

Mr.

Mr. *Nye* saith.

Inches.	lb.	Inches.
2	$1\frac{1}{16}$	4
2		4
	17	
4		16
2		4
8		64
		17
		448
		64
		1088

~~24~~	(8		
~~1088~~	(~~136~~	lb	ounces.
~~888~~	~~16~~	8	8

Now you may perceive, that they err only by neglecting to calculate their Tables. But as the Blind lead the Blind, so they both fall into the Ditch; for he gives 8 $\frac{1}{2}$ lb, or 8 lb 8 ounces.

And by Capt. *Sturmy* his Tables, I find a Ball of 8 Inches Diameter to be 58 lb 14 ounces; and yet he hath set down in his Tables a Ball of 7 $\frac{1}{4}$ Inches for 58 lb. And by the Tables of Mr. *Nye*, though he hath placed 71 lb; I can find by his working but 68 lb for the weight of a Ball of 8 Inches Diameter.

So this will be proved by the Line of Numbers: for if you say 4 Inches gives 9 lb, what shall 2 Inches give? place one foot of your Compasses in four Inches, and the other in 2 Inches; keeping the Compasses at the same extent, set one foot in 9, and measure downwards 3 of these Extents, which will reach to 1 lb 2 ounces; likewise say, if 2 Inches give 1 lb 2 ounces, what shall 8 Inches weigh? extend your Compasses from 2 to 8 Inches; the Compasses at the same extent, place one foot in 1 $\frac{1}{2}$ part, and three of these Extents will strike at 72 lb: But if the Weight of a Ball should be demanded in *Scotland*, you shall find a Ball of 1 lb is 2 Inches; and one of 4 Inches 8 lb; and 8 Inches Diameter (if you observe the

Work

Work of the Table) 64 ℔; you will find the ſame by uſing the Line of Numbers; in ſaying, 2 Inches Diameter gives 1 ℔, what 4 Inches? and by laying one foot of your Compaſſes in 2, the other in 4 Inches Diameter, and with the ſame extent ſet one foot in 1, and with three of theſe extents you ſhall find 8 ℔ weight: Thus you may do in finding the weight of Ball, knowing their Diameter to what Height you will; and find the true Weight either Scots or Engliſh, without being beholden to Tables; though you have in *pag.* 100, exact Tables Calculated Arithmetically from eight parts to eight parts of Inches unto 10 Inches Scots Weight; And in *pag.* 102 you have the like number of Inches Calculated for Ball in Engliſh Weight: This is the quickeſt way, and reaſonable true, if there be not holes in the Ball, or, as I have ſeen ſome, a great Ring about them, which might have taken up the Wind of the Peece.

Queſtion 6.

Pray you what Cautions or Circumſpections would you uſe in order to your Approaches making, that thereby the Army might have the leaſt hazard, and greateſt ſpeed to come to the Places where the Batteries are to be made for the Cannon, thereby to be more certain of a hopeful and good ſucceſs over the Enemy?

Anſwer.

To Anſwer this, you muſt know you may have many hinderances, if there be a reſolute Enemy in the Strength; Nevertheleſs obſerve;

1. You muſt be careful of your Leaguer, that it be well trenched and ſecure from fear of the Enemy, in all Quarters, by Trenches and Flank-works; then chuſe to ſet your Batteries moſt conveniently in the oppoſition of their Strengths, and obſerve that there be no Hill, nor deep Ditch to hinder the Souldiers, if occaſion offer to an Aſſault.

2. That your Approaches be intrenched to open or ſhut, and to make ſuch a way to come to the Batteries, and be ſure it be well covered and guarded with Men to keep it.

3. That the Platforms be large enough for the Guns to Reverſe, and alſo to command the Place they ſhoot at.

4. If there be Earth enough, that you make the Trenches deep and wide enough, and well flanked.

5. That

5. That with advice and deliberation, you batter all the high Flankers, the while you are making your Approach-Trenches.

6. When you have brought your Trenches to the Counterſcarp, then make your Platform and Brds for your Peeces by the Point of the Counterſcarp, by which you may hurt their Low-Flankers, and take them away; and ſo continuing your Battery that you bring down their Counterſcarp, and the body or face of their Work.

Queſtion 8.

When you are approached ſo near as you can, how ſhall you then Storm and Breach a Bulwark at the Point, that is both Offenſive and Defenſive?

Anſwer.

If you uſe thereto 18 or 20 Peeces, all Whole or Half-Cannon, and plant them ſo as they may ſhoot Right Angular, and croſs one the other; and if the Approach be ſo near as ought to be, I would have 4 of my Guns only play to diſmount the Enemies Ordnance in their Places, where-ever I could perceive they lay, and by this means make my Storm more free.

Queſtion 9.

If you were to ſhoot at a diſtance, what Gun would you chuſe, a Reinforc'd-Gun, or a True-Fortified?

Anſwer.

It is true, that if you elevate a Reinforc'd-Gun to 45 Degrees, and the True-Fortified to the ſame, ſhooting both one Ball, that then the Reinforc'd-Peece will drive his Ball more violently, and ſhall fly farther than the Ball of the True-Fortified-Peece: And great reaſon for it, the Reinforc'd is long and well Fortified; they of Braſs are 10 Diameters of the Bore about the Breech, and his Proof of Powder is ½ parts of his Balls weight, and ſome the whole Balls weight; and the True-Fortified but 9 Diameters of the Bore, which gives a great difference in Powder, for ſhe is proved with ⅔ parts of her Balls weight of Powder; beſides the one is longer, by half as long again as is the other; for the one being 18, and ſome 20 foot long, the other is but 10 or 12 foot long: by theſe Reaſons, being better Fortified, hath more Powder, more length, and but equal Ball; ſhe muſt burn more of the Powder before the Ball be delivered, which muſt of ne-

ceſſity more violently drive the Ball farther than the True-Fortified Gun.

Queſtion 10.

Thus it followeth, that the longer a Peece is, the more ſtrength ſhe hath, and doth violently carry her Ball farther.

Anſwer.

This is ſo to appearance; for as we ſay any thing conveyed through a Pipe or Bore, hath his Courſe more violent according as the Bore is long, and hath been found ſo to do by ſome: But I ſay, Experience teacheth otherwiſe now, for I have ſeen a Demi-Cannon tryed, being of a reaſonable length, and broke a foot and a half at the Muzzle; yet when the Peece was tryed again and again, did carry her Ball as far as ſhe did before.

Queſtion 11.

How is this, that a Sling doth ſhoot farther than a True-Fortified Peece, or other ſuch-like Peece, which is ſhorter than a Sling?

Anſwer.

I hold that which Reaſon and Experience both ſheweth: Namely, that the ſtrength of any Peece is ſo much more as the Peece is longer; but being fortified accordingly, and with this reſtriction, that it is done with an indifferent length; for from 8 to 12 foot long, being of the ſame Bore and Fortification, the Peece ſhall add to the flight of her Ball: But from 12 to 20 foot long, you ſhall ſee them abate of the Balls flight; the reaſon is, in all thoſe too long Guns, the Powder is burned before ſhe deliver her Ball, whereby the flame and ſtrength of the Balls flight is abated. This is ſtrange, and oppoſeth the thoughts of many Gunners; but by my Experience here in *England* by *Saltwich* I found it ſo, and therefore not to be controverted.

Queſtion 12.

But if you load a long Peece with ſo much more Powder, and being thereto Fortified, ſhould not that give ſtrength to the fire, that thereby the Ball ſhould more vehemently be farther driven?

Anſwer.

It is without all queſtion, that a Peece doth moſt harm having its greateſt Loading; yet it is found ordinarily, that in

all

all Guns having Powder above half the Balls weight, all taketh not fire; yea, I my ſelf at *Saltaſh* in *Cornwal*, gave a Quarter-Cannon, ſhooting 12 lb Ball, more than her ordinary allowance, and laying 6 pair of Sheets on the Ground, on the deſcent of the Ground; and after fire given, I found two ounces of the Powder whole, by which you may gueſs what more was burnt after it came out of the Peece by the flame; and ſo I ſuppoſe the Balls flight is not increaſed but diminiſhed: Whereby you may underſtand that too much Powder is diſadvantageous for Ordnance, and that there ought inſpection to be had to their Loading: And for theſe reaſons I have Calculated theſe Tables, which I am ſure is the neareſt Truth to give Ordnance their Powder, of any yet given out by any other. But I know ſome Gunners will be offended to think that by theſe Tables, the Fortification of their Guns conſidered, they ſhould be drawn to an Account of what Powder they have ſpent.

Queſtion 13.

If you were to ſhoot from the Battery G, in the Figure 133, to the Ship E; if you had your choice, whether would you uſe a Demi-Cannon or a Baſilisk?

Anſwer.

If it were a calm day, and the Sky clear, and the diſtance betwixt both about 300 or 400 Paces, then I would hold little or no difference which of the two to chuſe; but if it were a little Wind, the Sky thick, and the Air damp and moiſt, I would rather chuſe a Demi-Cannon than a Sling, or rather a Whole-Cannon than a Demi-Cannon. My Reaſon is this, That the Wind, and Miſt, or Rain, hath not ſo much ſtrength to divert a great Ball as a ſmall, which is found experimentally: for divers times I have ſhot from the Caſtle of *Edinburgh* to the Links of *Leith*, when the Enemy was exerciſing; but when there was a gale of Wind on either ſide, or againſt, I found the ſmall Ball to err; but the Demi-Cannon came much nearer my expectation.

Queſtion 14.

If you were to ſhoot from a Valley, as at the Point B, againſt the Hill A, or from the top of the Hill A to the Valley B; is there any difference in laying of the Ordnance?

Answer.

There are divers Opinions about ſhooting of this nature; for moſt do ſay, that ſhooting againſt the Hill from a Valley, the Ball will be below the Mark; and likewiſe ſhooting from the Hill to the Valley, that the Ball will ſtrike below the Mark; but as I have ſhewn by my own Experience, theſe Authors are not to be owned: for I doubt it is with divers that have writ of Gunnery, as that the Proverb will hold good, *viz.* Many Men ſpeak of *Robin Hood*, that never ſhot in his Bow. So I doubt ſome have writ they know not what themſelves, never being experimented.

Queſtion 15.

By this I perceive there is no Rule, or Fundamental Ground can be made, by which you can make a Table of Randoms, whereby the Gunner may lay his Peece to ſhoot ſuch Diſtance by ſuch Degrees of the Quadrant being thereto elevated.

Anſwer.

This I affirm, and my Reaſons you have in *pag.* 122, which if any Man will truly conſider, he will either not think to aver Random-Tables, or otherwiſe to make Tables for every Gun that is made, and alſo for every Wind and Weather that is, when they are to make uſe of the Guns; and he muſt not forget to make Tables for every Ground he is to ſhoot over: Which will keep them at work all their lives, and never conclude to any good purpoſe.

Queſtion 16.

Is it poſſible to give a general Rule, that inſtantly you may plant your Ordnance on a March againſt the Enemy in the Field, when the General intends to give Battel?

Anſwer.

I believe not, becauſe of the many hinderances and impediments that do many times follow; for the Rule of Diſcretion is that which muſt then be obſerved, and the Order of the General, and therefore is carried a competency of Field-Peeces, which are to be planted at the Head of the Battel, and ſome betwixt the Vant and the Middleward, by 2 or 3 together on the Flanks and Wings of the Muſqueteers, being covered with the Wings of Horſemen, or as occaſion preſents and ſuffers them; ſome of theſe on the Front of the Army, playing with diligence on the Enemies Brigades; and if the Fields be plain

and

and even, then as the Army hath by them Cannon, Demi-Cannon, Field-Peeces and Slings, which may be planted for the greater annoyance of the Enemy at a greater distance; for every Regiment ought to have 2 or 3 Field Peeces, which must be planted at the Head of the Leaguer, and must stand a little elevated with Earth, (if possible); all these will cool the Enemy before the Battels draw near; and some of these Field-Peeces may be removed as occasion will serve, where they may gaul the Enemy so, that Gunners being Men expert, and having good Attendants, may be very advantagious to an Army.

CHAP. XXXIV.

The Order and Necessaries for Guns to march by Land, they having six Demi-Cannons, six Sakers or Demiculverings, with two Whole-Cannons, besides their Field-Ordnance.

BEfore the Train doth march, there goeth out Pioneers, each of which is furnished with either a Shovel, Scoop, Pickax, Crow ar Handspike; having for their Commanders, a Captain, Lieutenant, and two Corporals, with a Drum to every Company; who are to make plain the way for the Cannon.

After them first follow the 6 Sakers or Demiculverings, drawn with their respective Horses, with their Provision of Ball in Wagons, and their Powder in Wagons, besides there must be at the Rear of the Cannon, if any whelm, help sufficient to mount them again.

Next follow them six Demi-Cannon, with their Shot and Powder conform; Then two Whole Cannon, with their Powder and Ball accordingly.

Then the Carriage of Ladles, Sponges, and Rammers, Match, Crows, and Handspikes, and Budg-barrels: These besides the Field-Peeces for the respective Regiments, take a great many Horses, Wagons, and Men, for their Attendants.

Now when the Cannons are on their March, every Gunner to his respective place, must march at the right side of his Peece,

Peece, and by them their Harbingers, who take notice of all the Ropes, and other Proviſions for Draught, and help them if defective; and alſo to ſee that the Axtrees be well ſoped or tallow'd, that thereby the Train may march without ſtop: The Wagon-Maſter muſt have ſpare Horſes by his Draught, if any fail either in Wagons, or in Draughts of the Ordnance. Several have given Rules for ſo many Horſes to a Peece of ſuch a Weight; as thus, every 500 lb of Metal for a Horſe-Draught; where the Gun is alone, beſides the Carriages, muſt have 120 Horſes: So I reckon for Guns, Carriages, and ſpare Horſes, there will be 180 Horſes: Now for Powder, Ball, and other Proviſions, 100 Horſes more with Wagons, beſides Wagons for the Officers.

This is ſuppoſed to be for ſo many Cannon in fine plain Way; but the Horſes in every Country are not all alike, for I have been drawing Cannon, and allowed but to every Horſe 350 lb, and hardly able to perform; but ſure it is, where Horſes are to be preſt, there need no halt to be made for Draught, if the Conductors be provident. But if there ſhould fortune Cannon to be drawn in places where Horſes or Oxen (for if you order a Yoke of Oxen for a Horſe-Draught it will be equal) are not to be found; Therefore I will ſet down a general Rule, how theſe Guns may be drawn by the ſtrength of Men. And the Calculation ſhall be made for the forenamed 14 Guns; by which may be reckoned any other Draught having the Weight.

Firſt, It is conceived an indifferent Man will draw 100 lb for his part, (but on a plain way); therefore for ordinary, I do allow a Man to draw 80 lb weight: And you will find, counting the weight of theſe 14 Peeces thus, The Cannon 7000 lb a peece, is 14000 lb for them two; then the Demi-Cannon 4500 lb, and theſe 6 are 27000 lb; for the 6 Demi-culverings 3200 lb apeece, and theſe will weigh 19200 lb; which in all is 60200 lb: which ſum being divided by 80, (the pounds of draught for one Man) will make 752 Men to draw the 14 Peeces of Cannon. Now theſe 752 Men to employ with diſcretion and good order, that every Man may do his endeavour, you are to make faſt your Ropes in this manner, on either ſide of the Carriage; before on the Hackes one Rope, and on the middle of the Bolt or Breſt-band one; And upon

upon every Rope, ſhall be ſo many Ropes ſo made faſt, as every Man may have 2 ½ foot diſtance one from another; ſo that the Draught-Ropes for a Demiculvering muſt be 17 fathom long: Now for the Demi-Cannon and Cannon, they may be reckoned by their proportion; ſo the Men are ſet to Work, as the Figure hereby doth ſhew.

This will be thought a new Invention, but I uſed the ſame in my Lord *Middleton*'s Service from *Aberdene* to *Fyvie*, where I cauſed them to make theſe Sled-feet, as you ſee faſt to the Carriage, in this manner; near to the Breech of the Peece there is a Bolt, whereon the end of the Sled-foot is; and under it, at the foot-end of the Carriage, a Square-hack to lay over the Sled-foot, and then a Rope through the Sled-foot: And a Man or two thereby ſhall ſteer a Gun by a Height or Hole, in the way where ſhe is to be drawn, ſo that many times it ſaves the Guns from falling over.

And when you are to meet your Enemy, or make uſe of your Guns, you may lift up your Sled-feet, and lay them all along the ſide of the Carriage in manner as you ſee, on a Hack where they do not trouble, and unhacking the Ropes from the Hacks before, you may uſe your Gun at your pleaſure.

CHAP. XXXI.

By knowing the Weight of one Peece of Ordnance true-bored, to find the Weight of another true-bored Peece, being of the ſame Metal.

BEcauſe it falleth out ſometimes, that in a Fort or Ship are Guns, not having their Weight deſcribed upon them; Therefore in ſuch occaſions, not to let the Gunner be to ſeek, but that he may give her Weight without great trouble, I ſhall here ſet down ſome Examples, whereby the Gunner may with eaſe find the weight of any great Ordnance, whereby he may be able to ſhew, what ſtore of Horſes or Men are competent to draw theſe Ordnance, if occaſion require.

Theſe Examples and Rules I intended to have given by a Gauge-Rule; and becauſe theſe ways are more eaſy to do,

and

and quicker dispatched, I shall only take by the way to let you know, that I will admit there is a Brass Saker weighing 1900 ℔ Weight; and as it is given out in other Questions, she is 3 $\frac{3}{4}$ Inches in the Diameter of the Bore: Now it is commonly found, these Guns are about the Breech, measuring at the Touch-hole, 9 Diameters of the Bore: I say then, if I bring 3 $\frac{3}{4}$ Inches all into Quarters, then I have 15 Quarters; with which I multiply the 9 Diameters of her Breech, and I find them 135 Quarters; which dividing by 4, I bring again to whole Inches, and find 33 $\frac{3}{4}$, which we will here call 34 Inches, for the Circumference of her Breech: Then I say by the Rule of Three; As 22 is to 7, So is 34 to 10 $\frac{9}{11}$ Inches.

The Work.

22	7	34	(1
		7	23(8(10 $\frac{18}{22}$ $\frac{9}{11}$ Inches.
		238	22 2
			2

This 10 $\frac{9}{11}$ of Inches, is the Diameter of that Saker; if she be true-Bored, she is true-Fortified: And such are the only Guns to make choice of for finding by their Weight, the Weight of any other Brass Peece: Therefore, I say,

Example.

If a Gun of a 11 Inches Diameter at the Chamber weighs 1900 ℔; What shall a Peece of 18 Inches Diameter weigh?

Thus by the Table of Logarithms.

The Logarithm of 11 Inches, is	1.041393
The Logarithm of the greater, 18 Inches, is	1.255272
Difference increasing	213879
	3
The Triple whereof is	641637
The Weight of the known Peece is 1900 ℔	3.278754
Sum is	3.920391

Which is the Logarithm of 8325 ℔, for the weight of the great Gun.

Here

Here you see that this operateth well by the Table of Logarithms, and the Weight of the Peece is found to be 8325 lb. Now to find the same by the Line of Numbers on the Scale, you are to place one foot of your Compasses in 11, and the other in 18; keeping the Compasses at the same extent, set one foot in 1900, and then triple turning the Compasses, the last foot will touch at 8325, as before.

Another Example.

Also there is a Peece, I know not what her Weight is; but I find the Diameter of this Peece to be 8 ½ Inches: And I place the Work to find her Weight as before.

Behold the Work.

The Diameter of the known Peece is 11 Inches	1.041393
The Logarithm of the Diameter of the other 8 ½	0.929008
Difference decreasing	99385
	3
Triple of the Difference is	298155
Which Subtracted from the Logarithm of 1900	3.278754
Rests	2.980599

Which is the Logarithm of 956 ⅓ lb, for the weight of the lesser Peece, which was required.

The weight thus found by Logarithms, you will find the like by the Line of Numbers, if you extend your Compasses from 11, the known Diameter, to 8 ½, the Diameter of the Peece whose weight you would have; the same extent three times from 1900 down the Scale, will reach to 956 ⅓.

This former Work you may find on the Line of Numbers, if you place one foot in 9, the Diameter of the Bore that begirts the Peece at the Touch-hole, and the other foot in 7, which is most near the Diameter that begirts the other Peece, and the Compasses at the same extent, place one foot in 1900 the weight of the known Peece, and three times turned downward, will light on 956 ⅓, as before.

CHAP. XXXVI.

By knowing the Weight of one Peece of Iron Ordnance, to find the Weight of another Peece of Iron Ordnance.

SUppose an Iron Saker of 3 ¼ Inches Diameter of the Bore, this Peece weigheth 1600 lb; I find all such Peeces to have 11 Diameters of the Bore about the Breech; for which cause I work as before, and bring 3 ¼ into quarters, which I multiply by 11 the Diameters of the Bore about the Breech, and I find 165, which I divide by 4, to bring again into Inches, and the Quotient is 41: Then I say, by the Rule of *Archimedes*; As 22 is to 7, so is 41 to 13 $\frac{1}{11}$ Inches.

22	7	41	
		7	287
		287	

The Fraction is so small not to be valued.

So that I find 13 Inches to be the Diameter of an Iron Saker, whose Weight is 1600 lb, and that the same is a true-Bored, true-Fortified Peece: Now there is an Iron Peece whose weight I know not, but I find the Diameter of that Peece at the Touch-hole or Charged Cylinder to be 21 Inches. To find the weight of this Peece Logarithmically.

Example.

I say, a Peece of Ordnance of Iron, of 13 Inches Diameter, weighing 1600 lb; What shall an Iron Peece of 21 Inches Diameter weigh?

The Work will ſtand thus.

The Logarithm of 13 Inches, is	1.113943
The Logarithm of 21 Inches, is	1.322219
Difference increaſing	208276
	3
Triple of the Difference is	624828
The Weight of the known Peece 1600, is	3.204119
Sum is	3.828947

Which is the Logarithm of 6744 lb, for the weight of the Peece inquired.

If you will work by the Line of Numbers on the Scale, you will find it near the ſame; for if you place one foot of your Compaſſes in 13 Inches the Diameter of the known Peece, and the other in 21 Inches the Diameter of the Peece whoſe Weight you deſire to know; keeping your Compaſſes at the ſame extent, ſet one foot in 1600, the Weight of the known Peece, turning your Compaſſes three times up the Scale, and you will find the third extent will reach 6744, which is the weight of the Peece required.

Another Example.

There is alſo a Peece of Iron Ordnannce, whoſe Diameter I find in the charged Cylinder to be 8 ¼ Inches; the Queſtion is, to find her Weight.

The Log. of the known Peece, 13 Inches is	1.113943
The Log. of the other Peece, 8 ¼ Inches is	0.916454
Difference decreaſing	0.197489
	3
Triple of the Difference is	0.592467
Which ſubtracted from the Log. of 1600	3.204119
Reſts	2.611652

Which is the Logarithm of 409 lb, for the weight of the Peece inquired.

Finding here the weight of this Peece to be 409 lb, you see it followeth, that great or small Ordnance their weight may be found; yet for variety we will have another Example.

Example.

I will admit there is a Peece found, whose Diameter is 10 ½ Inches; and the Weight of this Peece I demand.

The Log. of the known Peece, 13 Inches is	1.113943
The Log. of the other Peece, 10 ½ Inches is	1.021189
Difference decreasing	0.092754
	3
Triple of the Difference is	0.278262
Which being subtracted from the Log. of 1600	3.204119
Rests	2,925857

Which is the Logarithm of 843 lb, for the weight of the Peece inquired.

This and the former is found on the Line of Numbers, if you extend your Compasses from 13. to 8 ½. and with the same extention turned three times down the Scale, you have 409 lb. If you extend from 13 to 10 ½, and with the same extent from 1600, three times turned down finds 843 lb for the weight of the Peece inquired. And so much for the finding the Weight of Ordnance, thereby to provide what Horses, Oxen, or Men are able to draw them. As the Figure here demonstrates.

Having, as I suppose, satisfied the Gunner for what is incumbent for him to act both by Sea and Land, with all sorts of great Ordnance, either true-Bored, Taper'd, or Chamber-Bored: Now it remains that I satisfy my Friends, who expect to hear something of those Peeces that shoot Granado's, or other Fire-Works; as likewise of the Petard; and of their Ingredients, Compositions, and the manner of using them.

CHAP.

CHAP. XXXVII.

Of Powder and its Ingredients.

IT is a Parodox to many, to think that Salt-peter, Brimstone, and Coal, being incorporated, should be the only Compositions for Powder: But know this, That whosoever desires to learn to shoot in great Ordnance, or to make Fire-Balls, or any kind of Fire-Works, should learn to know the nature and sympathy of these three.

Salt-peter that is pure and of a Christal Colour is best; the refining whereof is set down by divers Authors, as *Mr. Nye*, and others; yet the nature of it is to burn downward, but if pure and well refined, will burn upward, with a great deal less noise.

Brimstone is hot and loves the fire, and the fire loves it; it is of a sharp nature; when you kindle it, it fireth upward; its colour is of a bright Yellow if it be good.

The Coal neither augmenteth nor diminisheth any strength or force of it self, only it soon taketh fire, by which the Salt-peter and Brimstone receiveth the fire, and perfecteth their Work: The best Coal is made of the lightest Wood, and the lighter the Wood is, the Coal shall be the better. And it is obvious to all, that when these two opposites, *viz.* Salt-peter and Brimstone are incorporate, and fired together, the Coal nourishing the fire, there is nothing can resist the force thereof, until the fire dissolve the whole in the Air.

Example.

If you load a Gun with Powder, (which is nothing but these Ingredients incorporate) or any other narrow Pipe, so soon as the fire comes to the Body, and the Composition is separate by the fire; then doth it force it self out to the Air so vehemently that nothing can withstand it.

Powder is made of divers sorts, as Cannon-Powder, Pistol-Powder

Powder, Muſquet-Powder, and Powder for Fire-Works.

Powder may be tryed three manner of ways; Firſt, Put your hand in a quantity of Powder, and gripe it hard, if it crack and make a noiſe in your hand, you may judg it is good; but if it crack not in your hand, it is either not well wrought, or it is ſpoiled.

The ſecond way, is by taking a little Powder, and put it on a ſmooth plain Board, or a piece of flat Stone; put fire to it, if it go up quickly to ſmoak, and leave no marks behind it, you may judg it good; but if it burn ſlowly, and leave white Corns behind it, then you may ſuppoſe it is not well incorporated, and hath too much Salt-peter in it, or that there is too much Duſt and Coal therein.

The third is by the Taſte; if it be too ſharp in the taſte, it is like to come moiſt; but if it taſte a little Niteriſh and Sweet, and hard-corned, it is good: There are ſeveral other ways to try the goodneſs of Powder, that for brevity I here omit.

Of Fire-Works.

There are ſeveral ſorts of Fire-Works, ſome for Offenſive Service, ſome for Defenſive Service, and ſome for Recreations and Sport: I intend only to ſpeak of thoſe which are to be uſed in earneſt, not minding to meddle with thoſe for Recreation at this time, in regard they are ſo learnedly treated by divers Authors.

Of Fire-Works, and thoſe Ingredients uſed for Compoſitions.

As there are ſundry and numerous Ingredients that may be uſed in Fire-Works; ſo Fire-Works are ſo to be mixed as they may work ſeveral effects, according to the ſeveral occaſions may be produced in War; therefore it is impoſſible for any Man to lay down Rules, which only muſt be obſerved; but that the Gunner may have a taſte of every Diſh, that are neceſſary to be uſed in bringing Enemies to Ruine, and Rebels to the Obedience of their Lawful Princes, obſerve theſe following.

The Loading and Uſe of the Mortar-Peece.

Theſe Peeces are not to be uſed as great Ordnance, in ſhooting at great Diſtances; but, as it were, to throw a Granado, or Fire-Ball, or Stones, over Walls, or into Gariſons, being ſeated high or low; or from a Gariſon to caſt a Ball into the Enemies Works or Batteries, thereby to fruſtrate them of their intents, by taking away thoſe Men moſt active in the ſame.

The Mortar-Peece may be elevated to any degree of the Quadrant; but the contrary you may obſerve in great Ordnance, for they cannot be elevated above 45 degrees; and the nearer you approach to any place to ſhoot at it, you muſt deball your Peece under 45 degrees; ſo that if Tables were to be made for Great Ordnance, they may not exceed 45; and Tables for Mortar-Peeces may be made from 1 to 45 degrees, and from 45 to 90 degrees.

Now he that would Load a Mortar-Peece, may elevate her Muzzle to what degree he will for his own conveniency: the Peece made clean, you put the Powder in the Chamber, and upon the Powder a Wad of Rope-yarn, Hay, or what you can provide; then you put a Turf of Earth cut on purpoſe, that is large, wider than the vacant Cylinder upon the Wad, which fills the Chamber, and then you put the Granado or other Fire-Work above that Turf, and putting Graſs or Hay about your Granado, that it may lie as you would in the Mortar, and alſo to keep the Powder in the Mortar from the fire of the Feuſee.

The Mortar-Peece being thus loaded, you cannot give fire, with any hope of ſucceſs, before you obſerve and know, how far the Diſtance is betwixt you and the place where you would have your Ball to light, and alſo know, how far that Mortar-Peece can caſt her Ball from Degree to Degree; likewiſe you muſt obſerve the Weather, whether it be calm, or blows hard, or if the Wind be with or againſt you, or if it be to the right or left of you: Having duly conſidered theſe things, the Gunner may do well the firſt ſhot; but if he err, he muſt amend the next.

So that it ſtands to reaſon, that when you have found the

Diſtance

Distance to the place you would lay your Ball at, that you may know by this Table near what Degree of the Quadrant the Peece must be laid to reach thither.

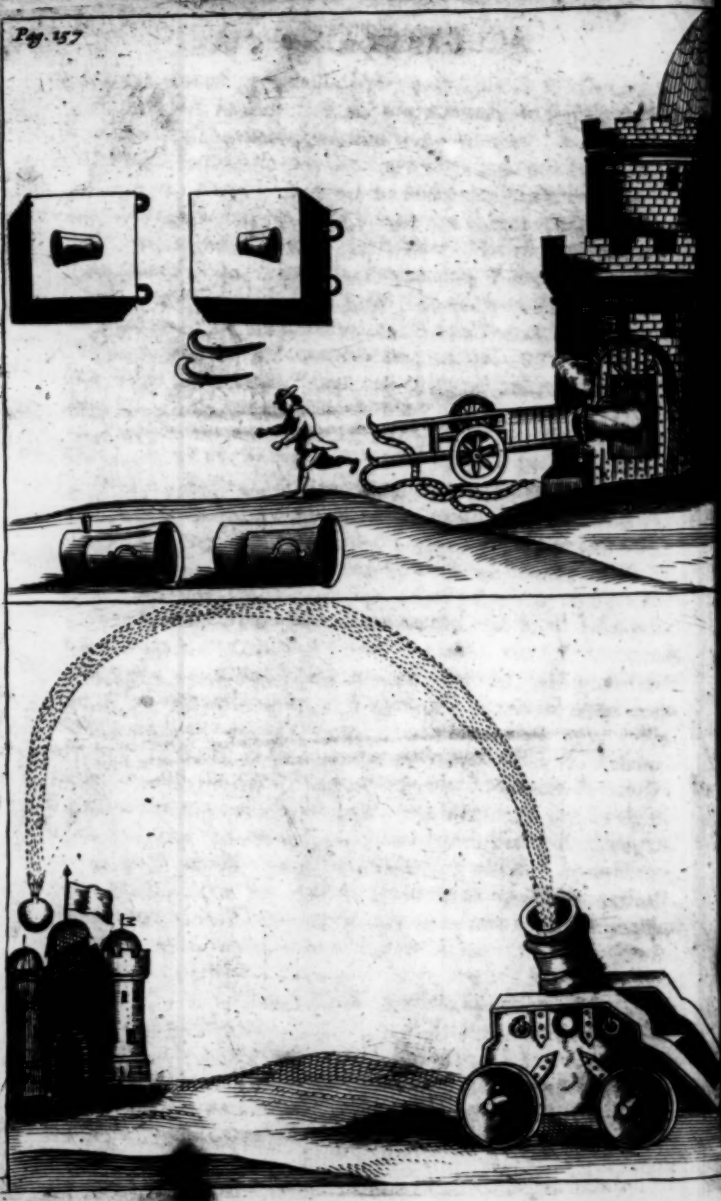
90	0		75	403		60	661
89	80		74	425		59	673
88	124		73	448		58	693
87	148		72	459		57	708
86	171		71	473		56	723
85	195		70	496		55	737
84	219		69	500		54	751
83	243		68	521		53	765
82	267		67	540		52	779
81	289		66	562		51	792
80	291		65	580		50	804
79	313		64	599		49	816
78	335		63	608		48	827
77	359		62	616		47	838
76	381		61	644		46	848

Now if you were with a Mortar-Peece at the back of a Wall near a beleaguered place, and there were a remarkable place, as Magazine, or Store-House, or Corn-Barn, and it is desired to lay the Granado or Fire-Ball in that place, the distance betwixt you and this place being found to be 243 paces, as in the Figure from A to M; Then look in the Table, and see what Degree is opposite to 243, and you will find 83 Degrees, and so the Mortar-Peece A must be elevated to 83 Degrees to cast her Ball or Granado into the House M. Do so with all other.

When you would discharge a Mortar Peece, first you must set fire to the Feusee of the Granado or Fire-Work, and you must see it burn well before you give fire at the Touch-hole, and mark narrowly where the fall is, thereby to help the next if need require, in form as aforesaid.

The Feusees for Granado's or Fire-Balls, may be filled with this Receipt; 1 part Powder, $\frac{1}{2}$ part Salt-peter, $\frac{1}{4}$ Brimstone, and $\frac{1}{4}$ part Rosin, being all well beat to Meal, and moistned with Linseed-Oil.

Now



Now follows the Proportion of the Petard, and Uſe thereof with all things belonging thereto.

The beſt Petards are made of Copper, to wit, $\frac{1}{10}$ part of Braſs: they are made of Iron alſo, ſome more ſome leſs, as the Figures ſhew: The Petard A is 12 Inches long, the Diameter at the Breech is $7\frac{1}{4}$ Inches, and the Diameter of the Concave is 5 Inches; then the one-ſide Metal muſt be $1\frac{1}{4}$ Inches thick; ſhe is at the Muzzle $\frac{1}{2}$ Inch thick, and the Diameter of the Bore at the Mouth is 10 Inches, and weigheth $76\frac{1}{2}$ lb.

There is another Petard as B, which is 9 Inches long; the Metal at the Muzzle is $\frac{1}{2}$ Inch thick, and by the Touch-hole 1 Inch thick; the Diameter of the Bore at the Mouth is 7 Inches, the Bore at the Breech 4 Inches.

To fix your Petard to do good Service at a Gate, or Caſtle, or other Fort, or Gariſon; you muſt have before the Mouth of the Petard a good Oaken Plank of about 2 Foot in ſquare; this Plank may be banded with Iron, both on the one ſide and on the other, as the 2 Planks DD, both being but one Plank, but the Bands of Iron are on the one ſide croſs the other; the Plank may be 3 or 4 Inches thick; the Powder to the Petard B may be 4 lb, and the Powder to the Petard A about $6\frac{1}{2}$ lb; when you have loaded the Petards, and rammed the Powder home, you ſhall put in the Muzzle of the Petard a Wooden Tamken, which you ſhall beat home with a Wooden Mallet, till it be faſt enough; then your may fill the Chinks with hard Tallow, and melt Pitch or Wax and run round about the Tamken, that the Powder in the Petard may be preſerved from Water. When you are to apply the Petard, and make it faſt to a Gate, you muſt firſt bore the Touch-hole thereof, and fill the ſame with ſome Powder mixed with Linſeed Oil: but a Feuſee may be better, filled with the Compoſition for Granado Feuſees, that it may take time to burn before the Petard fire, that the Man may remove that made it faſt. To make it faſt, you muſt have two Hack-Bolts, as E, with Screws at the ends, which are to ſcrue into the Gate, where you have the Plank D, to which the Petard G is faſt with a Chain by the Ears in the middle, or by a Staple drove in the Gate, to which the Chain is faſt, as you ſee by the Figure G and D, to the Gate F; To

carry this Petard, you must have a Wagon with Wheels, as the Figure H: This Wagon must be as broad as the Plank before the Petard, having in the fore-part three sharp-pointed Iron Pikes, that when it is run at the Gate it may hold fast, that the Man or Men may stand thereon, and fix their Screws, to which they must make fast the Plank with the Petard: Then giving fire to the Feuse, and removing back the Petard, having done Execution to expectation, the Parties may enter according to the Commands given.

While this Work was intended for the Young Gunners Instruction, I hold it my duty to shew you that there is no Fire-Work that can be invented or made for Offensive Service, but the same will and may be made use of for Defensive Service; but some may be made for Defensive Service, which can hardly be useful in Offensive Service, as Barrels for smoaking out of a Mine, or Balls, or Bags to burn the Wood, or Rubbish cast in to fill up a Ditch, Powder-pots, and such like.

Granadoes to shoot out of a Mortar-Peece.

The Mortar-Peece shoots all sorts of Fire-Works; First, Granadoes, the Shells made of Iron; Secondly, Balls or Bags made of Canvas, in form of Granadoes; Thirdly, a Mortar-Peece may shoot Stones coated with Fire-Works, or Stones in the Night to fall among the Enemy, as if it rained Stones.

1. For the first the Iron Shell of a Granado must be filled with good Powder, and some well-powdered Brimstone mixt with it, that thereby the Powder may throughly fire the more suddenly. In your Granado you may put some little Balls of unquenchable Composition, that when the Shell breaks and brings down the Rubbish of a House, those little Balls may raise Fire afterward; which is fearful in a Garison, and is one of the greatest terrors can come among them.

Canvas-Balls for Granadoes.

2. These Balls must be made of strong Canvas; when you have made your Canvas-Ball, you may fill it with Sand, and then take two Iron Rings, and mould your Ball strongly in form as you see the Ball in the Copper Plate N° 3. But if your

Ball

Ball be of great weight, ſingle Line will not ſerve to mould your Ball, and therefore you muſt make it a great deal leſs than the Bore of your Mortar-Peece, both in regard of the moulding and coating of your Ball.

The Ingredients or Compoſition to fill this Ball.

Take Powder, Salt-peter, and Brimſtone, of each a like quantity, theſe you ſhall beat ſmall, and incorporate them together; moiſten them with Linſeed-Oil, and work them with your Hands till you make a Paſte, that it may ſtick together in ſmall Balls if need be; This is a ſlow Compoſition.

Another for the ſame.

To this Compoſition you muſt take 4 parts of Powder, 3 of Salt-peter, and 3 of Brimſtone; theſe being ſeverally beat to Meal, moiſtned with Linſeed-Oil, and wrought as aforeſaid; This is a good Compoſition.

Another for the ſame.

Take 12 parts of Salt-peter, bray it not very ſmall, and 12 parts of Brimſtone not ſmall beat, work them well together, and moiſten them with 2 parts of Linſeed-Oil; then take 6 parts of good Salt-peter, bray it as ſmall as Currants; incorporate theſe Ingredients, and make a Ball thereof as big as a Walnut; and if it burn as long as you may tell 30 ſoberly, then is the Compoſition both good and ſtrong.

When you have found your Compoſition good, you may fill your Bag at diſcretion.

In moulding, you muſt have 2 Iron Rings of the thickneſs of $\frac{1}{4}$ of an Inch each of them; the one 4 Inches Diameter, and the other 3; and as you mould the Ball, rive the Line through the Rings; to which you muſt have a Splice-Iron, or Marlin-Spike of Horn; a tack of Harts-Horn is good to do it with: In the largeſt of your Rings you may ſet your Feuſee; the Feuſee may be made of Wood, the Pipe bored; you may bore 3 or 4 ſmall holes near the lower end; it is the cuſtom of Feuſees to reach the middle of the Granado or Ball; you may

pierce this Ball when filled with Fire-Work, and put therein Iron-Pipes, loaded with Powder and Shot; but be ſure the Touch-hole be wide enough, that Ruſt doth not ſtop them from firing; theſe Pipes muſt be beat in, till their Muzzles be equal to the Line.

Then you muſt coat this Bag with theſe Ingredients following; Take Pitch, melt it, and put therein Oil till it be tough and pliable; then put ſome Powder in it; and if you take Hurds or Tow, and ſpread on a Table, run this Stuff upon it; then wrap your Ball therein, and open your great Ring for your Fuſee-Hole, and ſtop it with a Plug.

When you are to uſe this Ball, take out the Plug, and put therein your Fuſee filled; then load your Mortar-Peece, and ſet your Ball in the Mortar in the ſame manner you do your Granado; having laid your Peece as ſhe ought to be, then fire the Fuſee, and ſo your Peece: If this Ball fall near any thing that will take fire, it will burn, and do the Enemy great harm.

For thoſe Stones, that may be ſhot from a Mortar-Peece, if you dip them in Compoſition made for Water-Balls, with Pitch, Roſin, and Wax, When they are coming down (as it were from Heaven) into a Gariſon, it puts them in great fear, and makes them gather about the Fire.

Then you may have a Mortar-Peece loaded, and put therein Stones as big as a Mans Head; and laying her as the other, theſe Stones falling amongſt the People, put them quite out of Heart.

Another Granado for a Mortar-Peece.

If you make a Ball of Canvas, as is before ſhown, well moulded and filled with Sand, then melt Pitch and Roſin, and dip the Canvas Bag in it; but you may have Muſquet-Shot cut in two, and clap them on this Coat as full as the Bag can ſtand, as you ſee in the Copper-Peece N° 2; then coat it again, put in the Feuſee; and if you fire it among Men, it will do great harm, the Sand being put out, and the Bag fill'd with Powder.

Another for the ſame.

If you let a Pully-maker or Turner turn of hard Wood two half Balls to join each in other, as the Figure 2 demonſtrates; they two being joined make a Spherical Body, as you

ſee

ſee, then mould them ſtrongly together with Wire, and with a Goudg cut out little ſlices of the Wood, as may help lodg half Muſquet-Ball; then dip it in melted Pitch and Roſin one dip over, and ſet ſhot; then coat it again; this Coat being filled with fine Powder, and a Feuſee put into it, it will ſerve either to be ſhot as a Granado, or heaved as a Hand-Granado, and will do good Service.

To make a Compoſition for Fire-Arrows.

Take 2 parts of Salt-peter, 2 of Powder, 1 of Roſin, 1 of Brimſtone; pound theſe Ingredients very ſmall, and mix them together; then moiſten them with Brandy-Wine and Linſeed-Oil, or *Oleum Benedictum*; then fill your Bag of Canvas made for the purpoſe, very hard and full; then ſtick an Arrow-head through the Bag, and make it faſt with Twine, Rope-Yarn, or ſuch like; and put a Plug for the Feuſee-Hole, where you mind to fire it; then coat it over with Pitch, rub Powder in the Touch-hole, give fire to it, and ſhoot it where you will, and it will burn very well.

But if you would not have it burn, till it light at the place appointed, in regard you would not have it ſeen, you ſhall take a little good Tinder of a Fingers length, and put it in at the part you mind it ſhall take fire; put that Tinder in fire, and ſhoot it where you pleaſe.

There are Gunners, that when they have moiſtned their Compoſition, clap it about the Arrow, and then lay Canvas about it, and ſew it faſt, bore holes, prime it, fire it, and ſhoot it where they have a mind; but it muſt be coated firſt: The form of an Arrow you have in the Copper-Plate N° 5. You may fill the Hedg-hog N° 4, in the Copper-Piece with this Compoſition.

To make Fire-Trunks.

Amongſt Fire-Works a Trunk is one, for they may be made with eaſy charge; Firſt, Cauſe the Block-maker to make a Trunk of hard Wood, and reaſonable thick, (tho you make the Ball ſmall) you may put two Hoops of Iron about it, and at the great end leave Wood enough to make a Socket for the end of a Pike or Pole.

The

The Compositions for Trunks.

Take Brimstone, Pitch, and Wax, alike quantity, melt them over a slow Fire, and put thereto 2 parts of Salt-peter mealed, with ½ part of Verdigrease, and ½ part of Camphire; all these being mixed together, add ½ part of Linseed-Oil, stir it well about, and take Hurds, Tow, or Hemp, and make wet with this Composition, which you shall roll up in form of Balls; these Balls you tie together with Twine, and when they are cold, you bore them cross through, which Holes you prime with Powder-dust; you may make of these Balls as many as you please; you may coat these Balls with melted Pitch, and roll them in Powder-dust.

To Load the Trunk.

First, Load her with a quantity of Powder, as the Gunner thinks fit to carry out his Ball and not break the Trunk; then put home to the Powder one of those cross-bored Balls, and for his Wad to keep him to the Powder, take a little Meal-Powder moistned with Linseed-Oil and made into Dow; and upon that load Powder and Ball again; then put upon the Ball of this slow Composition; then load Powder, and then Ball, and then of slow Composition again, till your Trunk be full; Then take the Lance and make fast in the Trunk, and set him to your Shoulder in form of a Musquet; let one fire at the Mouth of the Trunk, and you may shoot these Balls round about where you please, and they will burn. These Balls may be used in Iron-Shell Granadoes, or in Wooden-Shell Granadoes, if they be so big as to contain them; for when the Granado breaks they will burn furiously.

To make Balls to shew light in the Night.

Take Antimony 1 lb, Rosin 1 lb, Brimstone 3 lb, Salt-peter, 1 lb, Coal 1 lb; make many Balls thereof, bind them up with Tow: If the Enemy lie near your Walls, Ditches, or Trenches, for your own satisfaction, you may fire one or more of these Balls, and throw them over, where you have any suspicion; These Balls will give you light to see, if any be near your Fortification. And if you find the Enemy, you may fire your great Guns of what sort you will for their annoyance, still throwing of these Balls to give light to know the Enemies proceedings.

To

To make an extraordinary Fire-Work, which being put into a Mine, or in a Breach for Storm; ſhall ſuffocate or kill thoſe who come in the Smoke of it.

Take of Horſe-Litter, that hath been ſufficiently ſpoiled by the Horſes, dry it in the Sun; likewiſe take ſome of the Dirt that Hogs have lain upon, and dry it alſo; dried Cow-Gall, old woollen Clouts, chop all theſe ſmall; then take 1 part of Wax, 1 part of Hogs-Lard, 3 parts of Powder meal'd, ½ part of Ratsbane, ½ part Orpiment brayed to Meal, ½ part Verdigreaſe; mix all theſe things together, and fill a Bag therewith being well coated, put a Feuſee into it, and give fire; heave it among the Enemy, or ſhoot it to them, it will do excellent Service.

But if you fill a Barrel of this Compoſition, and ſet it in a Breach where the Enemy is to ſtorm; if the Wind carry the Smoak from you, the more it burns, the more it will ſmoak; and I am ſure no Man can be able to act in that Smoak, ſo that you may have great advantage of your Enemy in contriving this Smoak; as Figure 8 in the Copper peece ſheweth.

To make a Fire-Work that ſhall ſtink fearfully.

Take Brimſtone 2 lb, Roſin 1 lb, Kitchin-Stuff 1 lb, *Aſſa Fœtida* 1 lb; melt theſe together, then take ſhavings of Horn, or the parings of Horſe-Hoofs that are dry, mix a good quantity with the former melted Stuff; then take Hemp, Tow, or Rags of Linnen, or Woollen, or Okam, as much as will drink up the Compoſition, and make thereof a Fire-Ball; this being roll'd in a little Powder meal'd, and Mans Dung; ſet fire to it, and it will ſtink ſo, as who comes in the Smoak will rather fly, than abide the Smoak, (if they be able); you may put this in Bags, and make Balls or Hedg-Hogs thereof at your pleaſure.

To make by Fire, in time of Storm, a Smoak among the Stormers.

Take a large ſtrong Barrel and pitch it cloſe, half full of Quick-Lime; then ſet in the middle of the Barrel ſuch a quantity of Powder in a cloſe Cask, that, when fire is given, may blow

blow the great Barrel, and all that is in it to pieces; and be ſure you put in this little Barrel a Pipe or Fuſee filled with Compoſition, that may reach through the great Barrel; Then fill the great Barrel full with the aforeſaid Lime, and lay it at the Breach, where the Enemy is to ſtorm; and when you ſee your beſt advantage, having a Train laid of purpoſe, you may give fire, and if fire come to the Powder, it will ſpoil thoſe about it, that they, by filling their Eyes, Throats, and Noſes, ſhall not be able to ſee, or walk: by this means the Beſieged may have advantage againſt the Enemy. If Lime were uſed for cleanſing the Decks, inſtead of Stones, I believe it would give much ſatisfaction at ſome times; but Quick-Lime is dangerous, if Water come to it unawares. This Lime is nothing but Lime-Stone burn'd, that no Water hath been near; then it muſt be very well bray'd, and made as fine (if poſſible) as Flower; the finer you make it, the greater harm it ſhall do to the Enemy; and being dry and light, will continue the longer ere the Smoak diſſolve.

Another Barrel in time of Storm.

But if you would play with your Enemy, you may fill your great Barrel with fine pibble Stones, Muſquet-Shot, and pieces of old Iron, in form of our Powder-Cheſts at Sea; this being fired, while they are thick about it, will make rare ſport for the Defendant, and make them afraid of worſe to follow; and then if you can ply them with Hail-ſhot from your Guns, and Small-ſhot, Hand-Granadoes may give them cauſe to retire, if they can, with the greater ſafety, as the Figure in the Copper-peece 10, doth ſhew.

The Proportion of Compoſitions for Offenſive Fire-Works.

1. Take one part of good Powder, one part of Salt-peter, and half a part of Brimſtone, and a quantity of Saw-Duſt, or old rotten Wood, which will make a great Smoak: Theſe being well mixed with Linſeed-Oil, and wrought under your Hands, until you make the Compoſition to a Paſte, that it may hold together to make Balls.

2. Take groſs Cannon-Powder 1 lb, Salt-peter 1 lb, Brimſtone ½ of a lb; pound theſe very well in a Mortar, or a Powder-Mill, and mix them together; moiſten them with Linſeed-

Linſeed-Oil, and work them well with your hands to a ſtrong Dow or Paſte, as is before-ſaid.

3. If you take very good Powder, beat it very ſmall, ſearce it through a Sieve, and moiſten it with Linſeed-Oil, work it to a Dow or Paſte; it is good if you make uſe of it preſently; for this Compoſition is too ſtrong to be kept, and therefore you may add to it half ſo much Salt-peter, and a little Brimſtone, then it may be kept.

4. If you take of the beſt Piſtol-Powder you can get, beat it very ſmall, ſearce it through a narrow Sieve, moiſten it with Linſeed-Oil, work it well, as is before taught, and you have the beſt and ſtrongeſt Compoſition without doubt amongſt all the others; but it is likewiſe too ſtrong to be kept long, and fearful, if dry, to be fired.

5. If you take groſs Gun-Powder, as much as you pleaſe, and as much Salt-peter, being moiſtned with Linſeed-Oil, and wrought as the reſt, with a little Brimſtone.

6. If you take 2 ℔ and a half of groſs Gun-powder, and 4 ℔ of Salt-peter, and 1 ℔ of Brimſtone, all well beat, and ſearced through a Sieve; then being moiſtned with Linſeed-Oil and wrought as before.

7. Take 1 ℔ and a quarter of Powder, 1 ℔ of Salt-peter, 3 quarters of a ℔ of Brimſtone, half a ℔ of Sponk, the Heart of Willow, or old rotten Wood rubbed ſmall; all theſe being moiſtned with Linſeed-Oil, work them well with your Hands as the other Compoſitions are.

8. To 4 ℔ of Powder, take half a ℔ of Brimſtone, and half as much Salt-peter as both the other; all theſe being well pounded and ſearced through a Sieve, (as aforeſaid) and being moiſtened with Linſeed-Oil, work as the reſt.

9. If to 2 ℔ of Powder you take 1 ℔ of Salt-peter, half a ℔ of Brimſtone, and half a ℔ of Coal or rotten Wood, theſe all being well moiſtned with Linſeed Oil, and wrought, this will make a good ordinary Compoſition.

10. Take to 1 ℔ of groſs Powder, 2 ℔ of Salt-peter, and the quarter part of theſe two of Brimſtone; theſe being all pounded and ſearced, and moiſtned with Linſeed-Oil, and wrought as formerly inſtructed.

11. If you take 1 ℔ of good Powder, a quarter of a ℔ of Brimſtone, and 6 ounces of Salt-peter; theſe being all moiſt-

ned with Linſeed-Oil, and well wrought; then you take one fourth part of Spunk, or Saw-duſt well rubbed, mix this Compoſition with it, and you have your deſire.

12. Take 4 ℔ of Powder, 1 ℔ of Salt-peter, half a pound of Brimſtone; theſe being moiſtned with Linſeed-Oil, and well wrought; Laſtly, Take half a ℔ of Roſin, and as much Pitch ſmall pounded, and ſearced through a ſmall Sieve, and then a little Saw-duſt mixed therewith, with rotten Wood rubbed ſmall in your Hands; this is for the flame or ſmoak: If you would have it to ſpread abroad, put ſome brayed Glaſs therein. This Compoſition may be uſed amongſt your Recreations, but it is not to be long kept.

13. Take of Muſquet-Powder 12 Ounces, Coal 4 Ounces, Brimſtone 3 Ounces, moiſtned with a little Linſeed-Oil; this being well wrought may be likewiſe uſed.

Theſe following Compoſitions ſhould not be moiſtned at all, but made altogether dry, and ſo uſed.

1. Take what quantity of Salt-peter you will, and the fourth part of that of Brimſtone, with a little Powder, and a little Coal; all theſe being finely pounded, and ſearced through a ſmall Sieve; mix therewith ſome rotten Wood to increaſe the flame.

2. If you take 1 ℔ of Salt-peter, ½ a ℔ of Brimſtone a little Coal, and a little rotten Wood, the beſt you can have, to make a Smoak; the firſt two pounded and ſearced, and the reſt mixed therewith.

3. Take 2 ounces of Powder, 1 ℔ of Salt-peter, 2 ounces of Mercury; theſe 3 well poucded and ſearced; then 2 ounces of rotten Wood rubbed between your hands, and 2 ounces of Pitch; theſe two beaten ſmall not ſearced, mix them to the other Ingredients.

4. You may take 1 ℔ of Salt-peter, pounded and ſearced, a little Spunk, with a little Roſin; work the ſame as aforeſaid, then mix them all together.

5. If you take Salt-peter and Brimſtone, each alike, and a little rotten Wood; this is alſo a good Compoſition in Balls or Bags, and will keep long unſpoiled, and hath likewiſe no danger in the firing: It is eſteemed to be the beſt of all Compoſitions,

positions, and gives no strong fire, as the moistned Balls do.

6. Take 3 lb of Salt-peter, 1 lb of Brimstone, mix them with Coal, or rotten Wood which is light; if you use to these Balls Feusees it will not be amiss, or some of the slow Composition moistned with Oil.

All these may be made in Cloth-Balls, coated as aforesaid, and made use of as the Gunner pleaseth, for offending of an Enemy.

As there is nothing now unlawful, (though never so base) that can be acted against an Enemy; so it is very common for Persons to take upon them to be Spies and Intelligencers, who void of fear will enter with the Enemy in their Army, Leaguer or Garison, on purpose to betray them. Those Men who will give themselves to be Spies, they must certainly be of an idle and base disposition, void of the fear of God or Man, and subtil, secret, and Masters of all Villany; yet there are many simple Men, that for love of Mony do put themselves out for this use; these Men, altho they be instructed in what they are to go about, and how they may carry themselves in the same; nevertheless, either before or after they have done their Business, by some instinct of fear, otherwise by the Justice of Heaven, they are cast down, and by their own simplicity divulge something, which brings them to be apprehended, and through torture confess the Matter, and according to the Law of Arms receive Justice beyond other Malefactors, in regard the Offence of Treachery, under the colour of Friendship, is a Treason, and Treason is as the sin of Witchcraft, which will certainly be punished both by God and Man.

But if the Gunner should have occasion to use one of these for his secret Business, he should chuse one of those, who had been employed in such business before, and of such a nature, that though he be threatned, and asked questions seeming as though he might have been betrayed; nevertheless he must stand unalterably to his own innocency, without fear to change his colour, or coldness of heart to tremble; but with a merry countenance, dexterity in speech, knowing subtily to answer what is demanded.

I do remember, at the Line at *Leith*, when His Majesties Army lay there; one day there came a pretty subtil young Man from *Cromwel*'s Army, making his pretence that he had

left his Service of purpose to serve the King; he was brought before General *Alexander Leslie*, who put the Matter sleightly by, and gave the young Man leave and freedom to take Service where he pleased; whereupon he took occasion to go down the Line, see all our Army, and continued two days: I sent for the young Man, and in company I did alledg he was a Spy; he put it off with the finest Jokes that could be; assuring me, There was not a faithfuller Subject than he in the Army, swearing effectually to the point; but that Afternoon he went to the Enemy to receive his Reward; he was a sprightly young Man, but of a solid and discreet behaviour, that indeed I did admire his audacity and impudence; this Fellow was fit for a Spy.

Another; When I was in the Castle of *Edinburgh*, a Souldier, came running right up from the Enemies Works, that if he had been a Run-away, they might have killed him; but this Fellow came running into our Moat, and when he was there, feigned himself mad, and would be up; the Governour *Dundas* desired to have him up; so I caused hale him up by a Rope about his middle, (I am sure the Wall rubbed the Skin off his Hand); yet when he came in, he was slabbering, as it is said *David* did before the King of *Gath*, 1 *Sam.* 21. but hear what he would, and see what he would, he answered nothing to that purpose; but after he had been that Day and Night in the House with the Governour, he found the way back to the Enemy without help: Such as these are worthy to be Spies.

Now tho I will not encourage any Person to any Action so far below a good ingenious Spirit; nevertheless I will shew you what Fire-Balls they use, and the subtilty they use in the perusing those Fire-Works in laying of them: And therefore for Examples-sake, I will here shew the use of them, that thereby you may the better guard your selves from the treachery of Spies.

They use these following Fire-Works, when they intend to burn the Barns of Corn, or Store-houses where the Corn of the place lieth, or Powder-Magazines, in regard it is impossible for them to come into them, but that it is useful and necessary they have some Windows or Slits in the Walls, wherein they heave their Fire-Work, which is made in this manner.

Take one part of Colophony, or Rosin, two parts of quick-Brimstone,

Brimſtone, one part of Salt-peter, theſe three pounded very ſmall and mixed together, put to them ſo much Linſeed-Oil as will make the Compoſition like a Conſerve; then make Balls of the ſame, and if you will, you may make it for Arrows to ſhoot out of a Bow, or Croſs-bow, or by obſerving what is ſaid of Fire-Trunks, they may be uſed in the ſame manner, or they may be heaved by a Mans hand.

There are other Fire-Works that they uſe, as this ſtrong Compoſition.

Take 3 parts of Powder, one part of Brimſtone, which being pounded ſmall to Meal, mix them very well in a Bowl, put into them the bigneſs of a Walnut of Greek Pitch, or Colophony, which muſt alſo be ſmall ſtamped, and in the mixing you ſhall let ſome drops of Turpentine fall, as alſo a ſpoonful of Linſeed-Oil, and then make it to Paſte with Brandy-Wine, that if occaſion be you may make Balls of it.

But if you fill Bags with this Stuff, well pack'd together, and make therein a Hole, and put a ſtopper into it; then dip theſe Bags in the following Compoſition.

Take one part of Brimſtone, let it melt, and put into it one quarter part of Wax; when that is melted, put in one part of Pitch, and let that melt, and ſtir them together, take it from the fire, and mix into it one quarter-part of Powder.

Or Coat theſe Balls with this Compoſition: Take 3 parts of Brimſtone, melt it, and put into it one part of Wax, and one and a half of Greaſe, one quarter-part of Turpentine, and as much Vernice; when all is melted, ſet the Kettle a diſtance from the Fire, and put therein 3 parts of fine Powder; mix them, or ſtir them well together: when this is to be uſed, you ſhall take the ſtopper out of the Prime-hole, and in the place thereof, put in a piece of Match as long or ſhort as you pleaſe, according as you would have them to do execution. The making of this Match you are taught in *pag.* 172. To ſuch Actions as theſe the Match muſt be choſen that ſmoaks not, for they uſe to lie till a certain time, and ſmoaking Match will diſcover them.

Example.

I deſire a Fire to begin within 3 hours time, therefore I take a long piece of Match, which I intend to uſe; and I meaſure the ſame exactly; I light that Match, and mark how much of it

it burns ½ of an hour; I measure my Match again, by which I know how much is burned in the quarters time, and 12 times so much must be the measure of Match for the time appointed; it must be laid Serpent-like about the Ball, that the parts touch not one another, neither the Bag, as the Figure in the Copper-Peece, N° 7.

There are some may make use of the Fire-Arrow, which may be made sundry ways; some make them thus.

Take Powder ¼ part, 2 parts Brimstone, and 1 part Salt-peter, each well pounded to Meal, and searced; mix these three Materials together, moisten them either with Brandy or Linseed-Oil, and then melt Rosin, and pour it into Water, which makes it hard; then pulverize it, and take one part of it and mix with the former Ingredients; then pound them together very well till they are fit to make Balls of; then may you take of this Composition, and lay about an Arrow-Head, and wrap it about with Fustian or Canvas, and seiz it about the shank of the Arrow-Head; this Arrow-Head so armed, you coat it as other Fire-Works; then make a Priming-hole towards the point of the Arrow; stop it, and when you make use of it, fire and shoot it where you desire: As the Figure in the Copper-Piece, N° 5.

Here follows Compositions for Fire-Works for Storm, divers manner of ways.

1. Take Powder 4 lb, Salt-peter 3 lb, Brimstone 1 ½ lb, Rosin 1 ½ lb; these being all well beat and mixed together, and moistned with Linseed-Oil. This is a good Composition for Fire-Balls, and burns in the Water.

To make Fire-Balls to burn on the Water.

2. Take Powder 15 lb, Salt-peter 10 lb, Brimstone 4 lb, Rosin 2 lb; moistned with Linseed-Oil.

3. Take Powder 10 lb, Salt-peter 8 lb, Brimstone 2 lb, Rosin 1 lb; moistned with Linseed-Oil.

4. Take Powder 4 lb, Salt-peter 6 lb, Brimstone 2 lb, Rosin 1 lb; moistned with Linseed-Oil.

5. Take Salt-peter 8 lb, Brimstone 8 lb, Coal 1 ½ lb, Antimony

timony 1 lb, Amber 1 lb, Camphire 2 lb, Turpentine 1 lb, Rosin 1 ½ lb; all beat small and moistned with Linseed-Oil.

Another for Water-Balls.

6. Take Powder 9 lb, Salt-peter 7 lb, Brimstone 2 lb, dry Tanners Lee 1 lb; moistned with Linseed-Oil.

7. Take Powder 3 lb, Salt-peter 2 lb, Brimstone 1 lb, Colophony 1 ½ lb, Amber 1 ½ lb; moistned with Linseed-Oil.

8. Take Powder 6 lb, Salt-peter 6 lb, Brimstone 4 lb, Colophony 3 lb; all small beaten, and moistned with Linseed-Oil.

9. Take Powder 1 lb, Salt-peter 1 lb, Brimstone 2 lb; moistned with Linseed-Oil.

10. Take Powder 2 lb, Salt-peter 1 lb, Brimstone 2 lb; moistned with Linseed-Oil.

11. Take Powder 2 lb, Salt-peter 2 lb, Brimstone 2 lb; all beat small, and moistned with Linseed-Oil: These Balls may be used to Fire-Works and Fire-Balls.

12. Take Powder 2 lb, Salt-peter 5 lb, Rotten Wood, or Tanners Lee 1 lb, good Brimstone 1 lb, Salt 1 lb; these all beat small and mixed together, moistned with Linseed-Oil.

To make a long burning Composition for Fire-Balls.

13. Take Powder 10 lb, Salt-peter 4 lb, Brimstone 6 lb, Filings of Steel 4 lb, Sawdust 4 lb; and after you have moistned the Composition, mix the Filings of Steel and Sawdust amongst it; then make Balls of this Composition, and tie them as other Balls.

Another that is softer.

14. Take Salt-peter 5 lb, Brimstone 2 lb, Coals 1 lb, Sawdust 1 lb mixed amongst it.

15. Take Salt-peter 2 lb, Brimstone 1 ½ lb, Powder 1 ½ lb; these being beat small and mixed together; take Turpentine, melt it, and moisten these Ingredients in it.

Another Composition for Fire-Arrows.

16. Take Salt 8 lb, Brimstone 3 lb, Coals 1 lb, Sawdust 1 lb.

17. Take Salt-peter 2 lb, Powder 2 lb, Brimstone 1 ½ lb; you may use it to what you please.

For

For Powder-Pots, or Stink-Pots.

Take fine Powder, mixt with some Brimstone small beat; put therein some *Assa Fœtida*, some pieces of Verdigreese, and some Camphire: This heaved in a Ship's Round-House, Fore-Castle, or betwixt Decks, will make a fearful stink and smoak.

To make Match that shall not smoak.

Take a glazed Earthen-Pot, and put therein clean red Sand till it be $\frac{1}{3}$ full; coil therein Match, so that no part thereof touch other; then cover it well with the foresaid Sand, and coil Match thereon as before, and then put Sand above it till the Pot be full; which done, you are to put the Cover on the Pot, and lute it close, that no Smoak come forth of it; put this Pot into a Sinder or Charcoal-Fire, and cover it all over; let the Pot stand there till the Fire extinguish of it self; then take it out, shake the Sand off, and your Match is ready.

I could infinitely have added, but being straitned, do conclude, That as yet to the Art of Gunnery there is

NO END.

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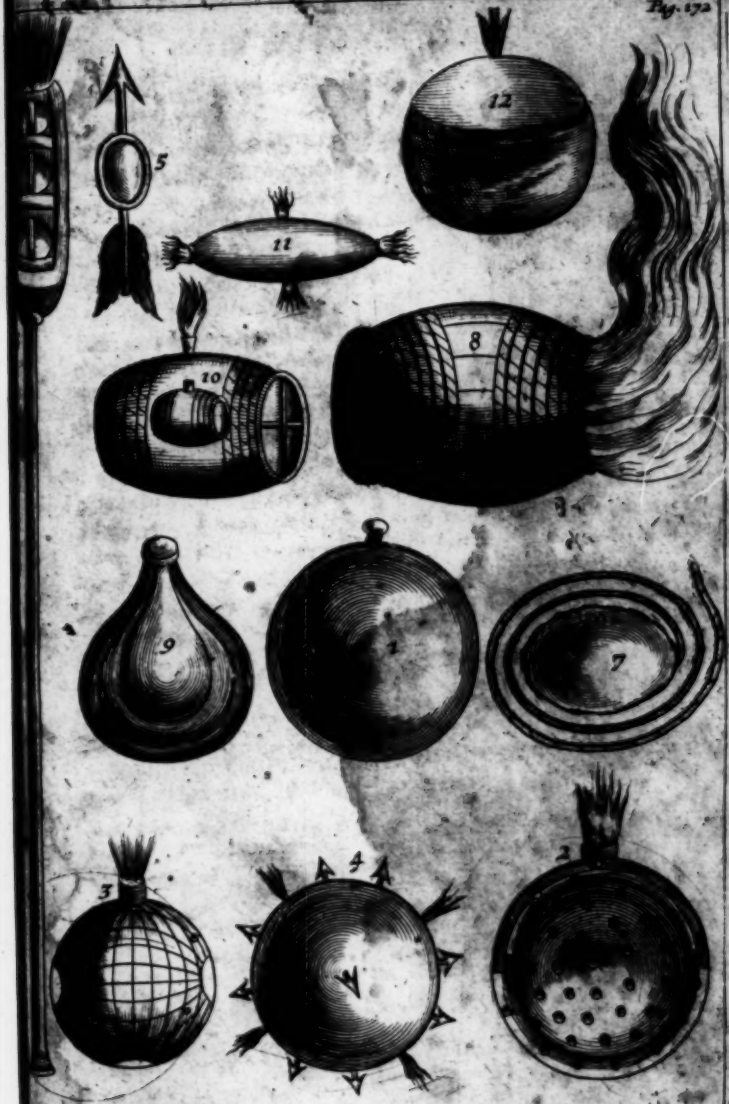
AT *Cherry-Garden-stairs*, on *Rotherhith-Wall*, are Taught *Arithmetick*, *Geometry*, *Algebra*, *Trigonometry*, *Navigation*, *Dialling*, *Astronomy*, *Surveying*, *Gauging*, *Fortification*, *Gunnery*, *the Use of the Globes*, *Projection of the Sphere*; and all parts of the Mathematicks,

By *James Atkinson*.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